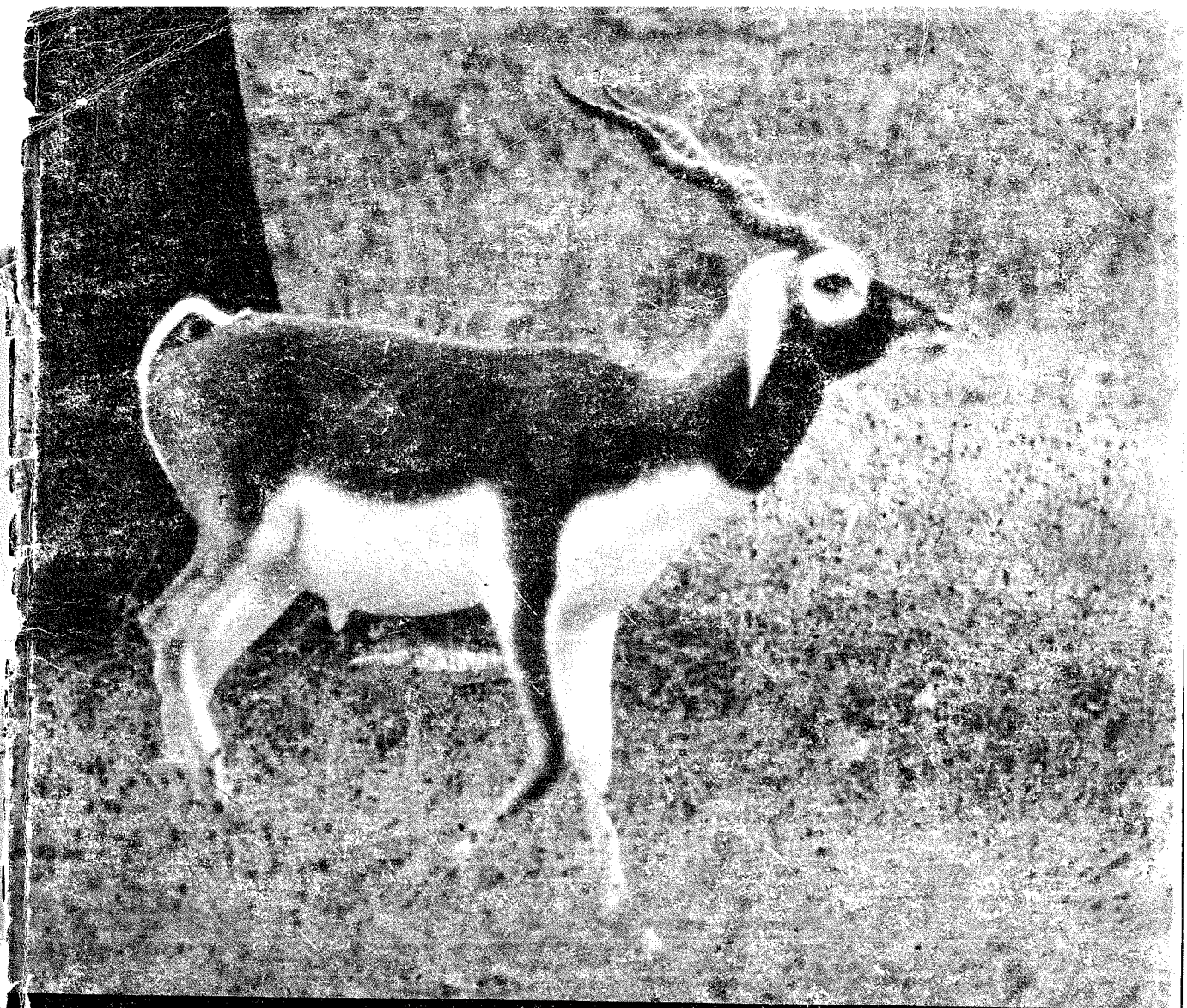

Kleberg Studies in Natural Resources

The Indian Blackbuck Antelope: A Texas View

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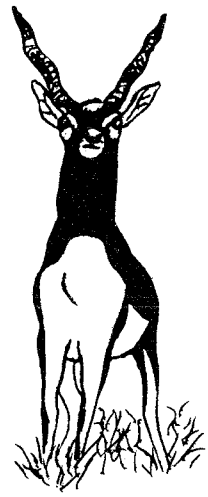

The Kleberg Studies in Natural Resources is a series of publications dedicated to the memory of the late Caesar Kleberg of King Ranch, Inc., who had a deep conviction that wildlife and the natural world are essential to the welfare of man. The Caesar Kleberg Foundation for Wildlife Conservation was established in 1946 in Mr. Kleberg's will because of the "great importance of wildlife and its beneficial effects upon the health, habits, and character of the American people." Thus his contributions to wildlife conservation and management continue after his death.

These wishes of Caesar Kleberg are being carried out by scientists of The Texas Agricultural Experiment Station, a part of the Texas A&M University System. James G. Teer, holder of the Caesar Kleberg Chair of Wildlife Ecology and head of the Department of Wildlife and Fisheries Sciences at Texas A&M, directs the program.

Kleberg Studies in Natural Resources

The Indian Blackbuck Antelope: A Texas View

Elizabeth Cary Mungall

The Caesar Kleberg Research Program in Wildlife Ecology

and
Department of Wildlife and Fisheries Sciences
The Texas Agricultural Experiment Station
The Texas A&M University System

This study draws together and integrates with existing literature the information gathered in a series of investigations conducted as units of the project "Management of the Blackbuck Antelope in Texas." Fieldwork was supported by the Caesar Kleberg Research Program in Wildlife Ecology at Texas A&M University. An NSF Traineeship helped support the first year of preliminary work and a Tom Slick Graduate Research Fellowship funded one year of the full-time field study. Other state and private organizations also aided the work at different times: notably Heart O' the Hills Taxidermy, Nowotny's Taxidermy, Texas Parks and Wildlife Department, San Antonio Zoological Gardens & Aquarium, the Upjohn Company and the USDA Toxicology Laboratory.

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Correspondence with K. S. Dharmakumarsinhji of Bhavnagar, India, has added to the project an extra dimension which would otherwise have been impossible. However, any misinterpretation of the Indian material is the author's, not his. To these people, to those who helped by commenting on the manuscript and to all the rest who aided in various ways, the project owes its sincerest thanks.

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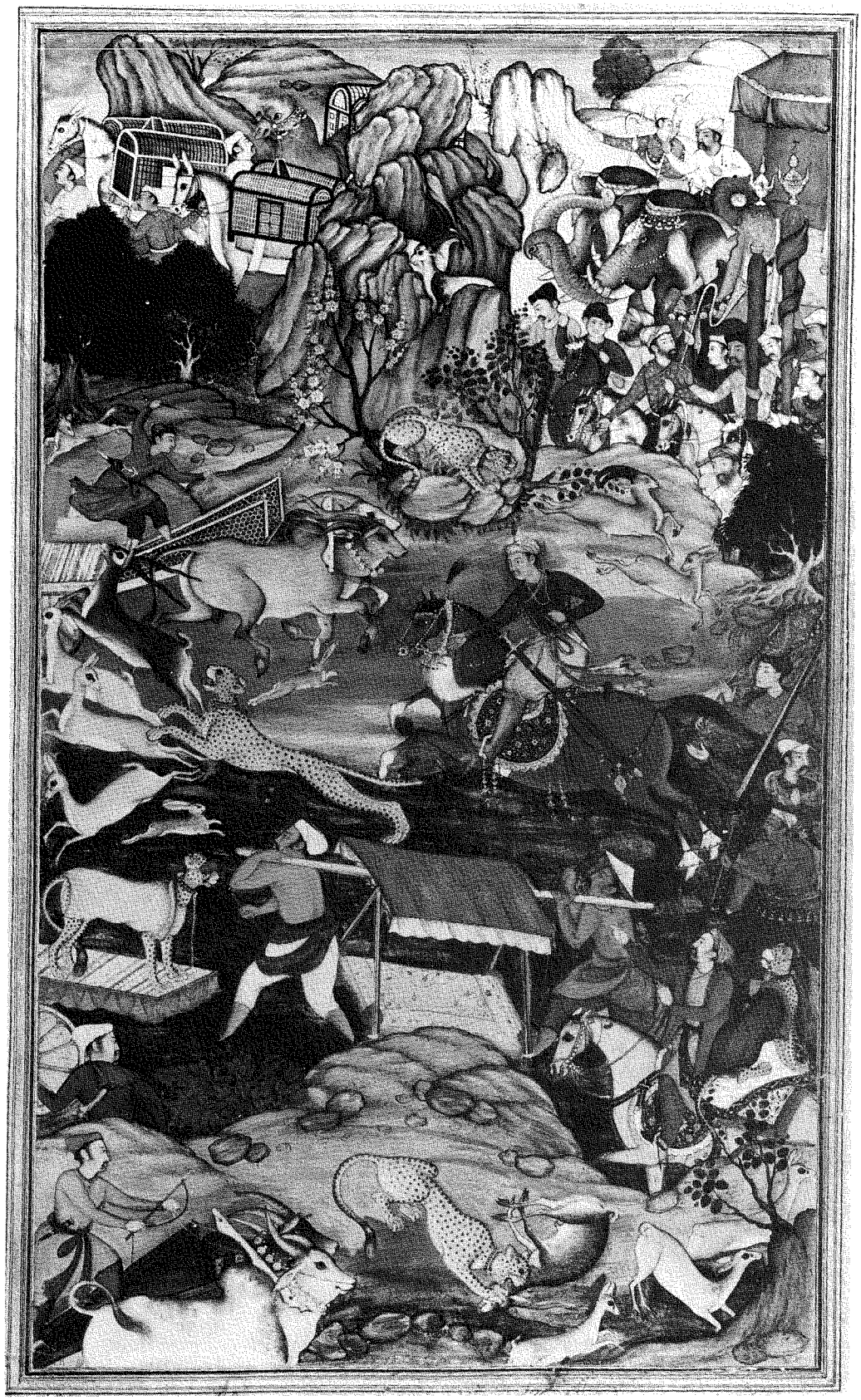
Table of Contents



INTRODUCTION

☐ With its spectacular rise in popularity as an exotic on Texas ranchlands, the Indian blackbuck antelope (*Antilope cervicapra,* L. 1758) has become a prime object for study. Not much is known about the blackbuck in its native India where numbers are declining steadily. Before the present study, even less information was available from Texas where owners need answers in order to manage their herds. Therefore, the Caesar Kleberg Research Program in Wildlife Ecology initiated a group of investigations carried out in Texas through the Department of Wildlife and Fisheries Sciences and the College of Veterinary Medicine at Texas A&M University.

The following summary presents the results of these investigations in the context of what other researchers — in Texas, in Europe and in India — have reported. In this way, a general picture is pieced together showing what the animal is like and how it operates within its environment. It is hoped this will lead to greater understanding and better management benefitting the species both at home and abroad. (For scientific names of species mentioned in the text, see Appendix A.)

FRONTISPIECE. Stages in a cheetah hunt shown in a Moghul miniature of Akbar hunting with cheetahs (Crown Copyright Victoria & Albert Museum).

1

HISTORY

☐ The blackbuck probably has been vaguely known to Europeans since Alexander the Great invaded the Punjab in 326 B.C. (Sclater and Thomas 1897-98, Ahmad 1958). Presumably, blackbuck were part of ancient India's vast animal trade which supplied live beasts to Roman governors and pets to Roman ladies (Basham 1959). If so, the blackbuck cannot have made much of an impression, for only the manuscripts from its native country give any detail on its status in early times.

Blackbuck during India's Moghul Period

Our best accounts of blackbuck from before the modern era come from the Moghul rulers of north, central and, eventually, parts of south India. When Babur, descendant of both Tamburlaine and Jenghiz Khan, and his followers left from their base around Kabul in 1525 A.D. and marched on Hindustan, they were essentially nomadic hunters (C

mation on Indian wildlife. Earlier material tends to be fragmentary and obscure (Rao 1957).

Importance of hunting

Even after the Moghuls became more settled, hunting remained an important activity. Trophies were judged by weight rather than by horn development, and no stigma inhibited taking females and young (Jahangir 1909, Rao 1957). Much of the hunting was nonselective. On the court's continual tours of the country, hunting supplied meat as well as sport. On a journey of 2 months and 10 days that Jahangir

made from Lahore to Agra, "No day either of marching or halting, on land or water, passed without sport. 114 deer [and 265 birds] . . . were taken on the way." (Jahangir 1914, p. 197).

At the same time the *qamargah* type of hunting offered peacetime military training as well as an awesome show of force to quell dissention without open hostilities (Abul 1873, Beveridge *in* Bābur 1922). The *qamargah* was a hunting ring of soldiers and other beaters that closed slowly keeping all game encircled. As the ring constricted concentrating the game, first the emperor, then the most prominent members of his retinue, next the other nobles and finally successively lower grades within his army and the footmen had their turns to hunt. By the time the beaters took their chance, the confusion was considerable. Occasionally this offered a convenient cloak for settling old scores (Abul 1972). The similarity to real battle has not been exaggerated. Customarily, old men or priests would eventually sue for the lives of the animals, and the survivors would be set free (Hookham 1962, Gascoigne 1971).

For an immense *qamargah* in 1567, Akbar employed several thousand men from rural Lahore — one account says 50,000 beaters (Beveridge *in* Abul 1972) — to enclose a starting area 96.5 km (60 mi) in diameter; over a month's time, the beaters slowly moved in until the diameter was less than 6.4 km (4 mi) (Gascoigne 1971, Abul 1972). The beaters had trapped about 15,000 animals (Badāoni 1973). Officers set up screens around the periphery and kept the game in with vigilance by day and with flaming torches by night (Abul 1873). The emperor mounted his horse and pursued the "prancing deer" for 5 successive days using arrow, sword, lance, musket and sometimes lasso before others joined the hunt (Abul 1873). Meanwhile, the ring continued to contract (Abul 1972). Under the increasing pressure from both inside and out, the animals became desperate to escape. During a hunt arranged for Akbar's father Humayun, a group of friends were fined a horse and a coin for each deer they accidentally allowed to break through (Gascoigne 1971). These hunts could go on for 1 to 3 months (Hookham 1962). One of Jahangir's (1909) *qamargah's* caught almost 300 animals, 95 of them antelope.

Using various hunting methods over a period of 3 months and 20 days, Akbar's son Jahangir (1909) and his party once took 99 blackbuck (68 males and 31 females), 44 chinkara, 3 hog deer (2 of them fawns), 108 nilgai, 8 *kūrāra* deer, 1 gāwzan deer, 12 tigers, 5 bears, 4 foxes, 3 hyenas, 6 hares, 1 *pātal,* 1 eagle, 1 bustard, 5 peafowl, 5 partridges, 5 herons, 5 *sāras,* 1 brahminī duck, 1 *dhīk* and 1,096 fish, for a hunt total of 1,414. A devotee of shooting, Akbar himself shot as many as 18 deer in a day (Jahangir 1909), and this total mounted steadily until he had killed more than 1,000 animals and birds with his favorite gun, Sangrām, alone (Abul 1873, Jahangir 1909). The numbers are prodigious, but so was the emperor's party. When the emperor was in residence in one of his major cities, an even greater number of people had to be fed from the royal kitchen. At the time of Muhammad Tughlak, such an operation is said to have required daily 2,500 oxen and 2,000 sheep as well as miscellaneous other animals and birds (Rao 1957).

Effect of hunting

Although an extended *qamargah* could decimate the wildlife populations of a particular area, the infrequency of visits to any particular tract, plus edicts forbidding unauthorized hunting, meant that game recovered. The blackbuck were especially noted for the large congregations that would build up in an undisturbed hunting place (Jahangir 1909). During a 6-year truce for the animals at Amānābād, the blackbuck became quite tame as well (Jahangir 1914). Both here and at Rūpbās Jahangir's ban on hunting was strictly obeyed, even when the blackbuck intruded on inhabited sections of Rūpbās (Jahangir 1909, 1914). Offenders could receive harsh penalties. Writing of new hunting prohibitions imposed by Jahangir's father Akbar, Abul Fazl 'Allami (1873, p. 200) writes, "This order was extended over the whole realm, and capital punishment inflicted on every one who acted against the command. Many a family was ruined."

Incidents at Amānābād and Samonagar give an idea of the heights to which animal numbers could climb when undisturbed. Blackbuck from the plains surrounding Amānābād were driven within an enclosure for a *qamarah.* Since Jahangir had previously vowed to give up

killing, he decided to transfer all the blackbuck to his polo grounds at Fathpur so that he could both enjoy the antelope and keep them safe. First 700 were taken, and then about 800 more were driven along a lane of screens thrown up for the purpose from the huntings grounds to the plain of Fathpur. (Jahangir 1914).

Earlier at Samonagar, Jahangir and his followers had killed 276 antelope (or antelope and deer) with arrows, guns and cheetahs, but on Sunday and Thursday, the days when Jahangir desisted from killing, the animals were netted alive. Of the 641 live captives, 488 were sent to the plains of Fathpur for release; 84 of these each went with a silver ring in its nose. (Jahangir 1909).

This proliferation of game depended on the common people restraining themselves from killing wildlife. As Aflalo (1904) points out, local sentiment which forbade killing in certain areas was instrumental in such abundance surviving into the times of the British raj. Areas lacking similar restraint tended — then as now — to become the sites of local extinctions as continuing pressure on a local level doomed the blackbuck. Crop protection, a desire for meat and increasing cultivation have all played their part (Seshadri 1969, Krishnan 1972).

Capture methods

Like the *qamargah* with its melee of mounted archers, lancers and footsoldiers, many of the hunting methods practiced by rural inhabitants were nonselective. The most common method of catching blackbuck was with snares (Brander 1923, Krishnan 1972). Popular materials for making snares were the dried and stretched Achilles tendons of blackbuck taken in previous hunts (Krishnan 1972). These snares were strong enough to hold even a large boar (Brander 1923). Snares were used in several ways. Men could spread them over an area of about 0.5 ha (1.2 ac) and then drive the animals over them, either with or without the aid of wings (Abul 1873, Percy 1894, Brander 1923). Snares could also be staked in patches of a favored food plant such as wild bitter-gourd (Krishnan 1972).

A most novel practice still employed as late as the 1920's was to attach snares to the horns of a tame buck and send it out to fight and entangle a wild rival (Bābur 1922, Ali 1927). According to Mons. de Thevenot, a foreign traveler during Aurangzeb's reign, the snares were fastened to the horns by means of a rope whose two ends were tied under the buck's belly (Ali 1927). A wild buck might conquer and get loose from as many as four tame bucks in a row, but keepers would continue to send fresh replacements until the wild buck succumbed (Abul 1873). This snaring method was also tried using chinkara but not with nearly the same success (Percy 1894).

Abul Fazl 'Allami (1873) relates that whereas formerly only two persons could go along and watch the struggle between the tame and wild bucks, his emperor Akbar introduced the practice of driving out some 40 domestic cattle so that more than 200 spectators could hide among the beasts and watch. Since blackbuck frequent cultivated areas, they are thoroughly accustomed to the sight of natives driving their stock about the countryside. Village shikaris and, later, some of the British also took advantage of this familiarity by using bullocks or bullock carts for stalking (Percy 1894, Stebbing 1911).

Sometimes hunters camouflaged themselves and their bows and arrows with green twigs or used a screen of leaves to stalk (Forsyth 1871, Abul 1873). Camouflaged hunters in ambush could be combined with a drive; at other times careful allowance for the wind could make a drive successful without elaborate camouflage (Abul 1873).

With some methods the object was to attract rather than to remain unobserved. The obvious decoys were other blackbuck. They could be held on a rope or with a large stone tied to one leg (Abul 1873, Percy 1894, Bābur 1922). An often-quoted passage (Percy 1894) describing how a buck and a doe could be used to bring a wild buck within rifle range is an example of the same technique (Fig. 1-1). The tame buck could not be too dark or appear too strong or wild bucks might refuse to approach (Percy 1894). After each success the decoys got a handful of corn before being taken to the next wild herd (Percy 1894).

In northern India blackbuck were hunted from camels bedecked with gay trappings and bells that would arouse the quarries' curiosity (Forsyth 1871). As Forsyth demonstrated, the fissures which develop in black cotton soils after the rains render central India unfit for hunt-

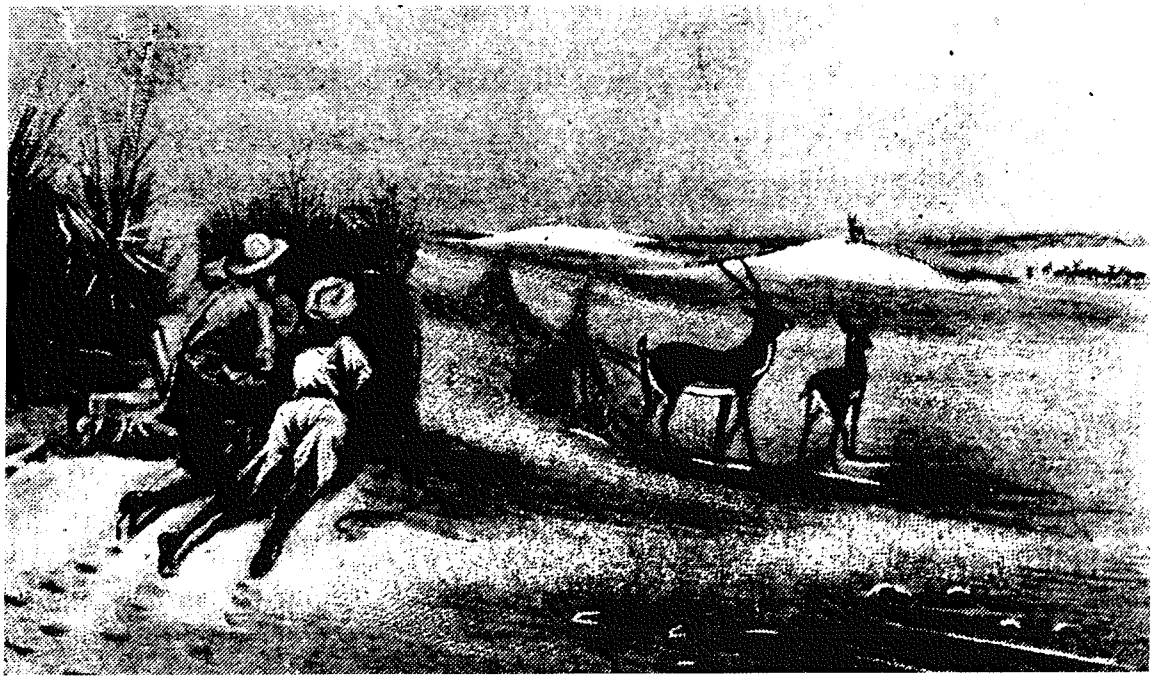


FIG. 1-1. Hunters in India using a pair of live decoys to lure a wild buck within rifle range (from Percy 1894).

ing from camelback. Akbar disapproved of using singing or musical instruments to lure antelope (Abul 1873). In one variation, a man concealed by the light of a lamp carried before him in the center of a concave shield rang bells to bring the antelope to an ambush by his fellows (Abul 1873). Additionally, a hunter might try to ambush antelope by imitating the quarry's calls, by throwing himself about as if mad or by pretending to be wounded (Abul 1873).

Some groups drove large numbers into nets, but this was not a general practice (Baldwin 1876, Bābur *in* Ali 1927). In the northern peninsula, a sharp, iron hook was pushed into a ripe bael fruit through the stalk scar and many of these fruits would then be scattered in areas used by blackbuck (Krishnan 1972). Biting hard into the bait to penetrate the outer rind, the blackbuck would drive the hook into palate or cheek; then, in its attempts to dislodge the point, it would immobilize itself by catching the hooves of a foreleg on a 20 cm (8 in) cord with a pencil-like sliver of wood dangling from the hook (Krishnan 1972). An adaptation practiced in the Parbhani district was to insert a hook and arrowhead into onions and tie them to a stake; the blackbuck were then attracted by the scent of the onions (Futehally 1975). Pits, drives into marshy ground and the slaughter of whole herds marooned by flooding were other ways natives armed only with spears or clubs could take blackbuck (G. 1909, Rao 1957, Seshadri 1969). In the 14th century, Bābur introduced primitive muskets to northern India; previously only the west coast had seen guns (Gascoigne 1971). However, it was nearly 400 years before firearms reached the village shikaris in significant numbers (Aflalo 1904, Seshadri 1969).

Other kinds of animals sent to hunt blackbuck were hawks, dogs, caracals and cheetahs. Large hawks were trained to swoop down on a blackbuck and molest it while dogs rushed in to secure it (Brander 1923). The lynx-like caracal was caught and trained to chase down gazelle, small deer and blackbuck as well as hare, fox, pigeon, crane and peafowl (Abul 1873, Prater 1971, Prakash 1975). Better adapted to racing after blackbuck was the caracal's larger relative, the cheetah.

Since a grown blackbuck male tends to keep near the end of an escaping group of females and since the coat of a dark buck stands out among the tan coats of does, bucks were somewhat more likely than females to be taken by a cheetah. Stages in a cheetah hunt are

shown in the frontispiece. The blindfolded cheetah wearing collar and leash was carried to the hunting ground, often in a bullock cart, and taken as close to the blackbuck as possible without stampeding the herd. Once the cheetah was slipped, it maneuvered into position and dashed in to grab its prey. The keeper then rushed up and dispatched the blackbuck. If acting strictly by the Moslem creed, a Moslem keeper would utter the word *"Bismillah"* (meaning "In the name of God") as he cut the blackbuck's throat; thus *"Hal lalled,"* the meat became lawful food (Baldwin 1876). Finally the keeper gave his charge blood from its "kill" and sometimes cut off a haunch for it to eat (Kinloch *in* Sclater and Thomas 1897-98). When beaters were used to gather the game, several cheetahs could be released at once in different directions (Abul 1873). Akbar collected the horns of all antelope killed by his cheetahs and used them to decorate towers which marked the periodic wells along the road he traveled yearly to Ajmír on pilgrimage (Badāōni and Blochmann *in* Abul 1873).

In Akbar's time regulations for feeding the cheetahs in the royal collection were strictly codified. Cheetahs who caught more antelope were rated above their companions, and according to the eight classes, the higher ranking animals received more meat (Abul 1873). Akbar once raised to the rank of chief cheetah an animal who leaped a ravine in order to follow the victim it had selected; in its new position, this cheetah was privileged to travel to the sound of a drum beaten before it (Abul 1972).

Hunting with cheetahs became so popular among the ruling families that some Indians turned to cheetah catching as a profession (Seshadri 1969). Many cheetahs were kept by a single household. Akbar collected roughly 9,000 cheetahs while on the throne (Iqbálnámah *in* Abul 1873), and he once had as many as 1,000 at the same time (Abul 1873, Jahangir 1909). All these animals had to be caught from the wild. The only litter of captive-bred cubs resulted when one of Jahangir's males broke its collar and mated with one of the ménage females (Iqbálnámah *in* Abul 1873, Jahangir 1909). Pairs let loose in gardens or other large enclosures never reproduced (Iqbálnámah *in* Abul 1873, Jahangir 1909, Gee 1969). When the Indian cheetah population began to fail early in the present century, cheetahs were imported from Africa (Gee 1969). The demand became so great that a youngster shipped from East Africa would fetch more than £100 (Mann 1934).

The last reliable report of a wild Indian cheetah came in 1952, the same year that the new Indian Board for Wild Life put the cheetah on its first list of species needing full protection (Seshadri 1969). The captive collections and the sport for which they were kept were dying out, too. Both the wild cheetahs and the huge blackbuck herds had disappeared before advancing human settlement and cultivation. The sole remaining cheetah, an African individual owned by the Maharaja of Kolhapur, whose hunting cheetahs had been famous in prewar days, died before the end of 1960 (Gee 1969, Seshadri 1969). The local blackbuck had already been finished off by poachers (Gee 1969).

Staged blackbuck fights

Staging blackbuck fights was no insignificant pursuit in its day. Many who could not afford to feed fighting elephants or lions found blackbuck, stags and quail within their means (Thevenot *in* Ali 1927). In addition to a stud where blackbuck were bred to fight and trained to catch more blackbuck from the wild, Akbar had 12,000 "deer" (the general Indian term does not distinguish among antelope, gazelle and deer) devoted to fighting exhibitions (Abul 1873).

Blackbuck fights may not have been as spectacular as elephant fights (Gascoigne 1971), but their following was still great enough that betting was carefully regulated. Men of higher rank could generally bet greater sums, and men of most ranks could bet more on blackbuck matches between first-class opponents than on wrestling matches; lower amounts were allowed for fights between water buffalo, cows, rams, goats and cocks (Abul 1873).

A complex system governed the keeping, rating and matching of the royal blackbuck. Akbar's biographer and contemporary Abul Fazl 'Allami (1873, pp. 218-221) describes the fights held for general assemblies, as opposed to those in people's private courtyards (Bābur 1922, Gascoigne 1971), thus:

> . . . His Majesty pays much attention to this animal, and has succeeded in training

this stubborn and timid creature. One hundred and one deer are *kháçah*; each has a name, and some peculiar qualities. A keeper is placed over every ten. There are three kinds of fighting deer; *first,* those which fight with such as are born in captivity and with wild ones; *secondly,* such as fight best with tame ones; and *thirdly,* such as fiercely attack wild deer. The fights are conducted in three different ways. *First,* according to number, the first fighting with the second, the third with the fourth, and so on, for the whole. At the second go, the first fights with the third, the second with the fourth, and so on. If a deer runs away, it is placed last; and if it is known to have run away three times, it ceases to be *kháçah.* Betting on these fights is allowed; the stake does not exceed 5 dáms. *Secondly,* with those belonging to the princes. Five *kháçah* pair fight with each other, and afterwards, two kháçah pair from His Majesty's hunting-ground; then five other *kháçah* pair. At the same time two pair from the deer park of His Majesty's hunting-ground fight, and afterwards five *kháçah* deer engage with five deer of the eldest prince. Then fourteen *kháçah* pair engage with each other, and fight afterwards with the deer of the prince, till the fight with the deer of the prince is finished. Upon this, the deer of princes fight with each other, and then *kháçah* deer. The betting on such fights must not exceed one muhur. *Thirdly,* with the deer of other people.

His Majesty selects forty-two from his nearer friends, and appoints every two of them as opponents, forming thus one and twenty sets. The first winners receive each thirty deer, and all others get one less, so that the last get each eleven. To every set a *Mal* [name for a Gujrát wrestler (Blochmann *in* Abul 1873)], . . . a waterbuffalo, a cow, a *quchqár* (fighting ram), a goat, and a cock, are given . . . . Before the fighting commences, two *kháçah* deer are brought in trimmed up, and are set against two deer belonging to people of various sets. First, with a deer belonging to a powerful grandee, and then the fight takes place before His Majesty. If a general assembly is announced, the fight may also take place, if the deer belongs to a commander of One Thousand . . . . As deer have not equal strength and impetuosity of attack, the rule among deer-keepers is, once to select each of their deer in turn and take it to the arena. Such deer are called *Aníu.* Another then estimates its strength, and brings a deer as opponent. The latter is called *Aṭkal* . . . .

. . . When the last pair comes, the betting is everywhere on the deer . . . .

The rule is that every one of such as keep animals brings on the fourteenth night of the moon one deer to the fight. The Bitikchí of this department appoints half the number of deer as *Aníns,* and the other half as *Aṭkals.* He then writes the names of the *Aṭkals* on paper slips, folds them up, and takes them to His Majesty, who takes up one. The animal chosen has to fight with an *Aníu.* As such nights are clear, fights are generally announced for that time.

Besides, there are two other classes of deer, *kotal,* and *half kotal.* The number of each is fixed. As often the number of *kháçah* deer decreases, the deficiency is made up from the *kotal* deer; and the deficiency in the number of *kotals* is made up from *half kotals.* One pair of *kotals* also is brought to the fight, so that they may be tried. Hunters supply continually wild deer, and bring them to His Majesty, who fixes the price. A fat superior deer costs 2 *M.* [muhurs]; a thin superior one, 1 *M.* to 15 *R.* [Rupees; possibly 1 *M.* to 9 *R.*]; a fat middling one, 12 *R.*; Do. lean, 8 *R.*; a third class fat one, 7 *R.*; Do. thin, 5 *R.*; a fourth class fat one, 4 *R.*; Do. lean, 2½ to 2 *R.* ["There is also a stud for deer, in which new results are obtained."]

Deer are kept and fed as follows: *Kháçah* deer selected for fighting before His Majesty, get 2 *s.* grain, ½ *s.* boiled flour, ⅓ *s.* butter, and 1 *d.* for grass. Such as are kept on His Majesty's hunting-grounds, *kotals,* and fighting deer of the sets, get 1¾ *s.* of grain, and flour and butter as before. The grass is supplied by each amateur himself. All

kháçah, home-bred, *kotal* deer, and those of His Majesty's hunting-ground, have each one keeper. The fighting deer of the sets have one keeper for every two; the single last one has a keeper for itself. Nothing is given for grass. Deer which are given to people to have them fattened, get 1¾ *s.* grain, and ½ *d.* for grass. They have one keeper for every four; but one for every two, if they are fit to become *kháçah.* Some deer are also sent to other towns; they get 1½ *s.* grain, and have each one keeper. If deer are newly caught, they get no regular food for seven days, after which they get ½ *s.* of grain for a fortnight. They then get 1 *s.*, and when one month is over, 1½ *s.*

In the deer park, Mançabdárs, Ahadís, and other soldiers are on staff-employ.

Just as there could be a chief cheetah, there could be a chief blackbuck. On the death of Mansarāj, a beloved antelope praised as unsurpassed whether fighting tame blackbuck or snaring wild ones, Jahangir had a *manār* shaped like an antelope placed at the head of the grave (Jahangir 1909). On this gravestone was carved a special composition by Mulla Muhammad Husain Kashmiri, the most renowned writer of the time:

> "In this enchanting place an antelope came into the world-holding . . . net of the God-knowing ruler Nūru-d-dīn Jahángīr Pādshād. In the space of one month, having overcome his desert fierceness, he became the head of the special antelopes."
>
> (Jahangir 1909, p. 91)

In honor of the dead buck, Jahangir (1909) made it unlawful for anyone to hunt the blackbuck of the plain his lost favorite's companions roamed or to eat their flesh. Further, Jahangir (1909) ordered that Sikandar Mu'in, jagirdar of the pargana, build a "strong fort" there in the village of Jahangirpur. At Seikhupura, this moated building still stands, elegantly mirrored in the water (Fig. 1-2) (Jahangir 1909, Gascoigne 1971).

There were special hospitals for the care of the fighting animals as well as other wild and domestic birds and beasts (Thevenot and Valle *in* Ali 1927, Rao 1957). Though conditions might be crowded, a European observer reported that the animals appeared to be looked after conscientiously and fed well (Thevenot and Valle *in* Ali 1927).

Science, religion and the arts

The Moghul writings reveal an inquiring mentality of the scientific sort. After inspecting the region known as Hindustan, the conqueror Bābur (1922) had a full report written. In addition to the sections on such topics as its people, physiography, climate and vegetation, it had a natural history section describing the animals observed and comparing them to their more familiar counterparts from Bābur's former home west of the Indus. The blackbuck is likened to the *jīrān.* Possibly *"jīrān"* means the saiga antelope (Beveridge *in* Babur 1922) which extended south to the Caucasus (Bannikov *et al.* 1967), but more likely the name designates the goitered gazelle (Ali 1927), a species inhabiting nearly the whole timurid territory from Persia to Beluchistan (Harrison 1968, Gascoigne 1971).

Bābur's great-grandson Jahangir (1909) recorded his observations on blackbuck milk and his surprise that any doe of this shy species would allow herself to be milked by human hands. Jahangir (1914) also tested the current belief that no blackbuck caught by a cheetah ever survives the experience even if released without scratch. A 13-day hunt within Pālam during which 426 antelope were taken offered a good chance for a trial (Jahangir 1914). Several strong, handsome blackbuck were rescued from the cheetahs without any sign of tooth or claw wounds and were placed under Jahangir's personal observation. All seemed fine the first day and night, but the second day they began to fling their legs about as if drunk and to fall repeatedly. A preparation of opium and "other suitable medicines" (Jahangir 1914, p. 110) were administered but with no apparent effect. After one watch in this state, all died.

In art, the attention to detail is reflected in the meticulous care with which scenes are reproduced. Artists painted accurate portraits of blackbuck and other animals to illustrate the recording of actual observations and events.

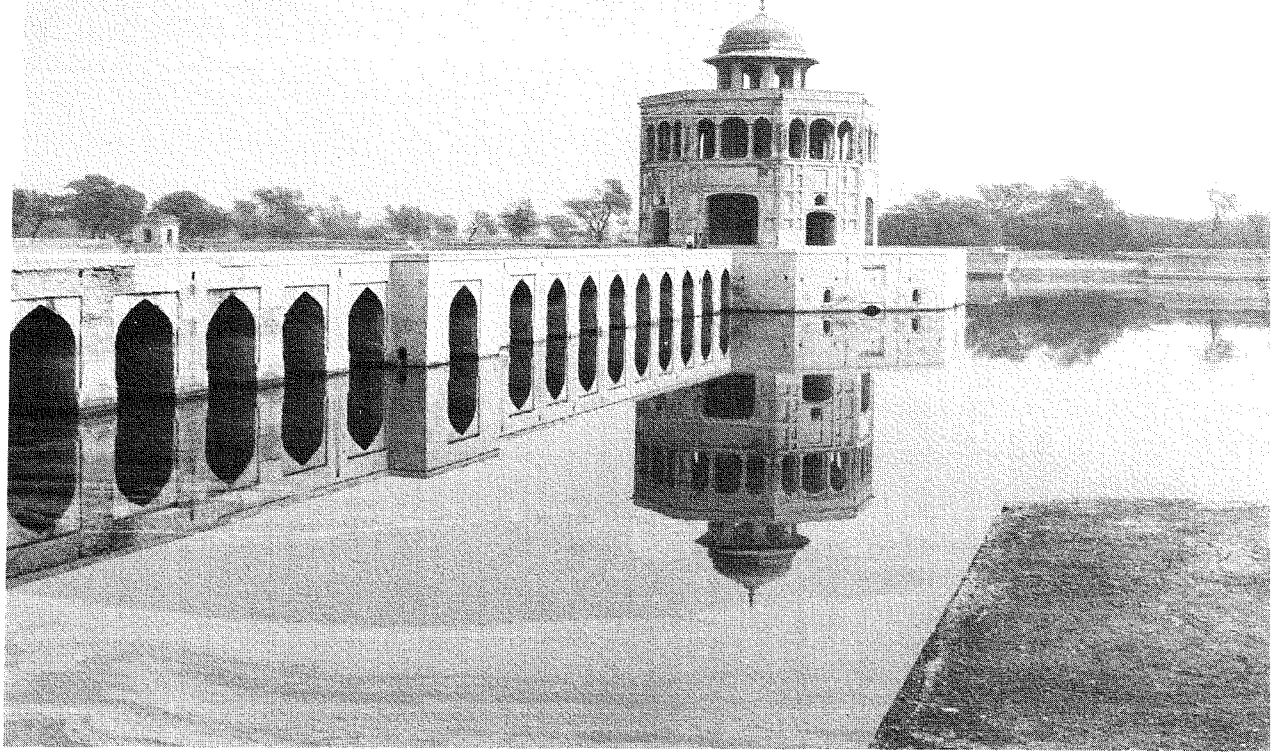


FIG. 1-2. Moated fort at Seikhupura ordered built by the Moghul emperor Jahangir in memory of his beloved antelope buck Mansarāj. (Copyright Christina Gascoigne.)

The picture on the back cover has been hailed as one of the prime examples of the Moghul school, which reached its peak under Jahangir (Havell 1920). Manohar Dās, creator of this picture, who served Jahangir and who later served his successor Sha Jahan, was a master of this style, which developed from a blending of Indian and Persian traditions (Havell 1920, Gascoigne 1971). Undoubtedly, many of the captivating Indian miniatures showing a buck strutting about in rich blankets and bells are pictures of successful challengers in the staged blackbuck fights.

Other common motifs are family groups of blackbuck fleeing hunters, blackbuck at peace among the rest of the wild community, collared blackbuck in gardens and a buck or a pair listening to a maiden play upon a musical instrument. In the latter two types the blackbuck can be a symbolic device rather than a literal record, for the buck can represent the maiden's lover.

The lively figures appear on printed cloths, on painted boxes and as brass votive objects (Fig. 1-3) as well as on the sculptured walls of temples and palaces (Dharmakumarsinhji and Gaikwad 1958, Bussabarger and Robins 1965). For more mundane uses, craftsmen fashioned blackbuck horns into items like the handles of yak-tail flywhisks (Lydekker 1907).

Charmed by the dark eyes of the blackbuck, poets used them to describe the eyes of beautiful women (Dharmakumarsinhji and Gaikwad 1958). Musicians remember the blackbuck with such melodies as the "Todi" and "Bhimapalas" (Dharmakumarsinhji and Gaikwad 1958).

Since the dark buck's white eye rings suggest the moon in a night sky, the blackbuck has a religious significance to many Indians. Because of sacred associations, local sentiment has protected the blackbuck in some areas (Aflalo 1904, Krishnan 1972, Prakash 1975). The Vishnoi community in Rajasthan even uses force when necessary to prevent their killing (Prakash 1975). In some districts a white blackbuck is considered unlucky and is driven away (Baldwin 1876; see also section on albinism in Chapter 8). The blackbuck is a constellation in the Indian zodiac (Jerdon 1874). It draws the chariot of the Vedic moon god, Chandra, as well as conveying two other Vedic gods, Soma and Vayu (Dharmakumarsinhji and Gaikwad 1958, Bussabarger and Robins 1968). *The Moonstone,* first murder mystery in the English language, gives readers a glimpse of the black-

FIG. 1-3. Brass blackbuck from Bihar showing traces of vermilion which is used in rituals. (Photograph from Bussabarger and Robins 1965, courtesy Dover Publications, Inc.)

buck as mount of the four-armed moon god who reigns as Regent of the Night (Collins 1946). To the god Shiva the blackbuck is a sign of good omen (Dharmakumarsinhji and Gaikwad 1958).

The blackbuck's inclination to shun dense cover brought it distinction in the sacred Hindu writings as a distinguishing feature of the regions appropriate for occupation by the Aryans (Forsyth 1871). These colonizers swept into India from central Asia between 2000 and 1000 B.C. and continued to push the Dravidians and other native groups southward as the northern plains and then the Deccan plateaus were occupied (Wallbank 1958). Brahmins offered the blackbuck as a holy sacrifice, and the devout prized buck skins as prayer rugs (Forsyth 1871, Baldwin 1876, Dharmakumarsinhji and Gaikwad 1958). The emperor Jahangir (1909) once ordered that the skins of the blackbuck killed by his own hand should be turned into rugs for the public audience hall so that people could use them when praying.

Two blackbuck horns joined together, sometimes with the ends shod with iron, became the weapons of religious Faquirs and Santons (Thevenot *in* Ali 1927). Kipling (1912), in his novel *Kim,* describes a Faquir wielding a blackbuck-horn staff against his human foe. Thus, no matter what direction India's traditions may take in the future, the blackbuck is an integral part of her cultural heritage.

Changing numerical status

Present blackbuck populations in their native habitat are only a remnant of the teaming herds familiar to past generations, but there are still enough for determined action to secure the species for the future. In Texas where blackbuck are nearing levels that can rival those in their native country, it is often said that the keeping of exotics on game ranches is of substantial benefit to the survival of the species. Ranches have even cooperated with the San Antonio Zoological Society and the World Wildlife Fund in sending breeding stock to Pakistan where blackbuck had become virtually extinct (DiSabato, pers. comm.). However, the benefits from Texas populations will last only as long as the popularity of raising exotics on ranch lands survives changing land use patterns, objections to raising exotics in combination with native species, sentiment against zoos, regulations hindering keeping or sale and rising costs which can render maintenance prohibitive.

Zoos in India and elsewhere have built up such thriving herds of blackbuck that after 1965 the *International Zoo Yearbook* discontinued listing the inventories from the different institutions separately every year and dropped blackbuck from some issues entirely. This very rise bears the seeds of its decline, however, for the increasing difficulty and cost of placing surplus offspring is now leading zoos to disband their herds of this "common" species.

India

There were once 4 million blackbuck on the Indian subcontinent, according to the approximation accepted by Groves (1972). Fig. 1-4

compares the former distribution with what is left today. The blackbuck was the most common as well as the most conspicuous of plains game and formed the largest herds (Lydekker 1907, Stockley 1928). Scott informed Jerdon (1874) that occasionally herds as large as 8,000 to 10,000 congregated on the government cattle farm at Hissar. The largest herds Jerdon had seen were of several thousand near Jalna in the Deccan. Parts of the Deccan and especially northwestern India were noted not only for the finest trophies, but also for the greatest abundance (Jerdon 1874, Blanford 1888-91, Lydekker 1907). Stockley (1928) tells of the time when there were aggregations of more than 1,000 in Bikanir and more than 500 in the Punjab. One January he counted 400 in a herd in neighboring Patiala but estimates that there were at least 100 more animals (Stockley 1928). As late as 1975 Prakash wrote that, in exceptional cases, as many as 500 blackbuck could still be seen together in Rajasthan, always a stronghold of the species.

Recent literature on the plains game of Africa has publicized its wealth of species and numbers. Wildlife in parts of India was no less abundant. Seshadri (1969, p. 18) cites Brander's (1923) impression of the area including today's Kanha National Park:

> "In 1900 this tract contained as much game as any tract I ever saw in the best parts of Africa in 1908. I have seen 1,500 head consisting of eleven species in an evening's stroll. It is nothing like that now, but it is probably true to say that it contains more numbers and more species than any other tract of its size in the whole of Asia."

Referring to blackbuck in particular, Forsyth (1871, p. 57) wrote:

> Although many of them are shot by the village shikaris at night, and more snared and netted by the professional hunters called Párdís (who use a trained bullock in stalking round the herds to screen their movements), the resources of the natives are altogether insufficient, in a country favourable to them, to keep down the numbers of these prolific and wary creatures . . . .

How, then, is it that such an abundant creature has declined so markedly?

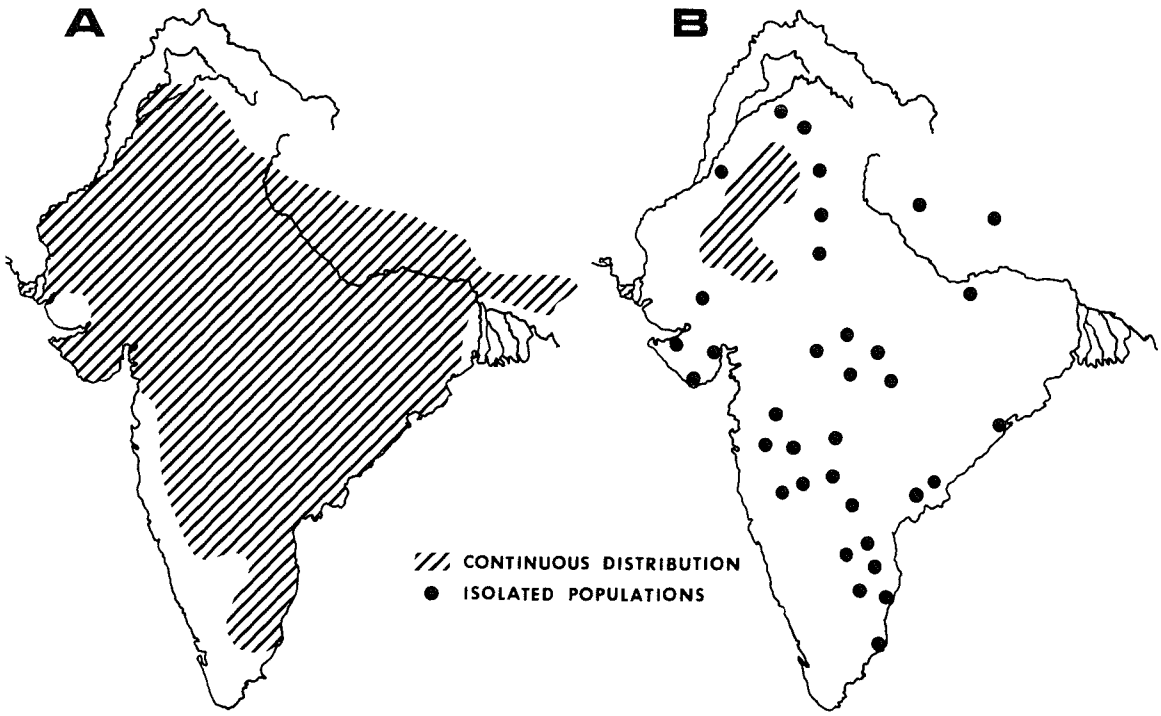


FIG. 1-4. Distribution of the blackbuck in its native India: (A) maximum historical limits and (B) present status. (Current distribution adapted principally from information collected by Schaller and presented by the National Geographic Society in Putman 1976.)

Ultimately, habitat destruction has made the crucial difference, but sport hunting during British rule began the downward trend. Soldiers and civil staff hunting for recreation thinned or eliminated conspicuous game like blackbuck from the vicinity of their quarters, although the British in India were never numerous enough to affect the remoter districts (Brander 1923). Furthermore, their hunting ethics precluded general slaughter. A comment by Stockley (1928, p. 142) in his book, *Big Game Shooting in the Indian Empire,* is revealing: "I do not consider that wearing native clothes or using a cart are fair ways of getting up to them [blackbuck]. It is always possible to outwit them, and the greater the difficulty the better the sport." Also, the shooting concentrated on grown bucks.

This is not to say, of course, that individuals did not kill large quantities of game. Baldwin (1876), for instance, killed more than 200 blackbuck during his career, and a report in *The Asian* (C. 1902) mentions a youth who palled of the sport after bagging 40 blackbuck in 3 months. One of India's prominent naturalists acknowledges that, "Forty or fifty years ago . . . we all shot; in a morning you could easily bag three or four blackbuck." (Ali *in* Putman 1976, p. 310). An avid shooter could account for 11 bucks in a day (Baldwin 1876). The largest count taken within the shortest period may well be the bag of 64 bucks in just under 6 days by two guns as reported by Percy (1894). Wounded animals were generally followed up if possible, and meat was not wasted. Either the carcass was used in camp or it was given to local people. A hunter's heavy indulgence in "buck-shooting" tended to be offset by growing disenchantment due to abundance of the sport (Forsyth 1871, C. 1902). As early as the turn of the century the diminishing numbers of blackbuck in tracts opened up by the railroad began to be lamented (G. 1909). It was a foregone conclusion that where the railroad went, hunters followed.

Between the two world wars, habitat loss became the significant factor in blackbuck decline as India's human population continued to expand more and more rapidly (Seshadri 1969). During this period, however, "when you traveled by train from Bombay to Ahmadabad, there was hardly a time after you left the settled areas that you didn't see herds of blackbuck." (Ali *in* Putman 1976, p. 310). Since wildlife was still so conspicuous in so many places, no vigorous protection program was instituted.

Then WWII escalated direct destruction. Army camps requisitioned wildlife areas; troops in training turned machine guns on game (Gee 1969, Seshadri 1969). Independence came in 1947 soon after the war, and many observers were pessimistic as to wildlife's chances. Guns and ammunition had become readily available, and the system of preserves and shooting laws formerly upheld by the British and the native princes broke down (Gee 1969, Seshadri 1969, Putman 1976). Now that the game belonged to the people, the people felt free to collect.

Nevertheless, order did return. The states demonstrated a growing sense of responsibility for wildlife by passing laws and authorizing sanctuaries. It took 5 years, but the central government finally found time to evaluate conservation issues and to set up the Indian Board for Wild Life in 1952 (Gee 1969).

Now the major problem for wildlife again became habitat destruction, but on a larger scale. Lack of coordination between groups involved with wildlife preservation and groups promoting economic development aggravated losses (Seshadri 1969). These groups had not learned that for some types of projects, careful planning can allow for wildlife's requirements at the same time that it caters to man's needs.

As examples of what can happen to wildlife when development schemes are undertaken, Seshadri (1969) discusses a number of cases. The Periyar River dam, built in 1897 to provide irrigation water, was constructed with little disturbance to flora and fauna. Later, hydroelectric capacity was added, but still the planners held disturbance to wildlife and habitat to a minimum (Krishnan 1971). Forty years later when the Maharajah of Travancore instigated the creation of a sanctuary centered around the lake made by the dam, wildlife still abounded in the region. Now the park's animals remain while the surrounding hills are largely devoid of wildlife.

By contrast, Tungabhadra dam repeated the pattern of all too many development projects undertaken since independence (Seshadri 1969). First there was a sudden influx of people as workers were moved to the site. Then indis-

criminate hunting by project personnel and visitors to the newly opened area finished off what larger animals survived the excessive land clearance that destroyed wildlife habitat. Until the Tungabhadra dam was built, blackbuck had been particularly numerous on the plains there. By 1951 when the dam was still in the early construction stages, lack of provision for sparing vegetation and wildlife not directly on the work sites was already obvious. Cover was disappearing fast, and heavy poaching kept the area markets stacked with blackbuck meat. The pleas for protective measures went unheeded. At completion of the dam there were no more blackbuck to protect.

The latter example illustrates a current problem. A new type of hunter has come to the fore in India. This one shoots from jeeps; at night any pair of eyes reflecting a spotlight becomes a target, and wounded animals run off without being followed up and dispatched (Seshadri 1969). These poachers tend to be "weekend hunters" who come out from the cities; sometimes they are such influential people that game wardens hesitate to interfere (Seshadri 1969).

Today, almost no wildlife survives outside of sanctuaries (Fig. 1-4). Even within sanctuaries, however, wildlife is by no means safe. Pay is low and staff often falls short in both numbers and training (Seshadri 1969). Poachers penetrate protected areas. Some sanctuaries are too small to meet the entire needs of the wildlife, so animals wander outside and come under increased hunting pressure (Seshadri 1969). In addition, sanctuaries are often open to grass gathering, tree cutting and overgrazing by domestic stock. These destroy food and cover. Some sanctuaries have whole villages within their borders. The Gir Wild Life Sanctuary is one.The herdsmen from these and surrounding settlements graze some 20,000 head of livestock within the sanctuary's 1,160 km^2 (448 mi^2) (Seshadri 1969, Berwick 1974). As many as 80,000 more cattle, buffalo and other domestics are herded in from outside the forest during drought periods (Putman 1976). Blackbuck disappeared from the Gir Forest about 30 years ago while other game species better adapted to brush habitats are found only in reduced numbers (Berwick 1974). India is only just awakening to the realization that protection of environment is necessary for protection of animals (Seshadri 1969).

Under persecution blackbuck have retreated more into open forest, wasteland and even moist areas and have become more nocturnal (Dharmakumarsinhji 1967, Seshadri 1969). That they show this adaptability is fortunate, since many of India's sanctuaries are forested areas and much of the open plains are needed for cultivation. Nevertheless, blackbuck have almost vanished from the Punjab (Singh *in* Oza and Gaekwad 1973). Only isolated herds of a few animals each remain, except in the Thar Desert area of Rajasthan in regions where blackbuck are vigorously protected by the Vishnois (Prakash 1975). The Thar population would seem to be vanishing, too. Today groups of as many as 20 are rarely sighted (Singh in Oza and Gaekwad 1973). Kanha National Park includes part of the area which, as already mentioned, was without parallel in quantity of wild life in the whole of Asia at the start of this century (Brander in Seshadri 1969). By 1953 Kanha had only 63 blackbuck (Gee 1969), and by 1965 there were only 20 (Schaller 1967).

This reflects the pattern throughout India. The Wild Life Preservation Society of India estimated there were 80,000 blackbuck in 1947 but only 8,000 in 1964; the losses continue (Seshadri 1969). Unofficial 1977 estimates range from 5,000 to 10,500. The difficulty of establishing a figure in the absence of detailed census data makes variation inevitable, but even the maximum value is a conservative guess. The largest single concentration is probably in Velavadar National Park (17.83 km^2; 6.88 mi^2) in Bhavnagar District of Saurashtra, Gujarat; this population totals about 1,500 in spite of a disastrous cyclonic storm with flooding which caused nearly 1,000 deaths in 1976 (Rashid *in litt.*). The largest concentration of blackbuck in south India is believed to be in Point Calimere Sanctuary which has about 750 to 800 (Daniel 1967).

The plains of Nepal once held thriving herds of blackbuck. A wildlife survey reported by Spillett and Tamang (1966) found a few blackbuck near Sukla in the Kanchanpur District; they consider some of the areas of short grass in the large, open grasslands of the Sukla Phanta vicinity as the main hope for blackbuck preservation in Nepal. The small populations in

the Mainapokhar area in the Bardia District and in west Nepal's *terai* (northern extent of the Indo-Ganga plains) in the Bankey District were both endangered by overgrazing of domestic livestock (Spillett and Tamang 1966). Today, this overgrazing plus cultivation and hunting have reduced Nepal's total to 15 to 25 blackbuck; the government is now investigating ways to move them to a more protected place (Lehmkuhl *in litt.*).

Pakistan's blackbuck population has fallen into worse straits. As late as 1945 the Cholistan desert still held large herds (Bokhari 1970). Because of mechanized poaching, the only blackbuck left by 1970 were a few in precarious residence near Fort Abbas plus the occasional migrant from India which was quickly shot (Bokhari 1970). At this juncture the San Antonio Zoological Society, under the auspices of the World Wildlife Fund (WWF), was able to send the new Cholistan wildlife reserve, Lal Suhanra, three males and seven females (Anon. 1970a, Anon. 1970b, Bokhari 1970). This breeding stock had been donated by Texas Hill Country ranches (Anon. 1970b, DiSabato pers. comm.). Five young were promptly born, but no immediate gain was realized because one female had died in transit and four females and fawns died as a result of accidents before their 0.8 ha (2 ac) enclosure at Lal Suhanra could be enlarged (Mountfort 1970-71). Upon the expansion of the sanctuary as a whole from 220 to 388 km² (85 to 150 mi²), a second WWF(US) offer of blackbuck can be acted upon; the plan is to maintain the breeding enclosure for several more years while setting surplus stock at large on the rest of the reserve which will also be fenced (Mountfort 1970-71).

India has also tried relocation efforts. In 1970 the Fauna Preservation Society sponsored the collection of nine blackbuck to stock the new Bandhavghar National Park, created at the insistence of the Maharaja of Rewa from his private hunting reserves (Wright 1972). Even though he had inquired as far away as Texas, the Maharaja's zoological advisor had been unable to obtain any more blackbuck after releasing one pair (Wright 1972). The FPS project found four females at the Calcutta Animal Market but lost the smallest who was already in poor condition (Wright 1972). Several months later the Chief Conservator of Forests in West Bengal allowed five blackbuck to be taken from his herd at Shantineketan (Wright 1972). Two of the three females caught were pregnant and one died after the rigors of the 800 km (500 mi) truck trip, but the other seven of "Operation Blackbuck's" charges were safely freed in the park (Wright 1972). Although such relocation efforts may jeopardize the integrity of subspecies, the chances that the species will survive are increased.

Texas and Argentina

In both Texas and in Argentina, virtually all concentrations of exotics are on private property. Argentine releases began in 1906 with game Pedro Luro imported for his huge *estancia* in the southern pampas; he brought in blackbuck as well as axis deer, fallow deer, red deer and wild boar (Barrett 1968). The blackbuck mix freely with the cattle, and on some ranches in eastern Argentina the blackbuck have become so numerous that thinning "by hundreds" has been necessary (Barrett 1968, p. 93).

Details of the blackbuck's introduction in Texas are impossible to trace, since some of the principal people involved are dead and few records were kept. Blackbuck are noted for their ability to reproduce well in zoos. Nevertheless, the possibility of their establishing viable populations when set loose on the range was not seriously considered in the beginning. Instead, the animals were brought to ranches to add variety for the viewing pleasure of owners and their guests (M. Sikes pers. comm.). Area resident Mangum Sikes recalls it was in the 1930's that friends urged him to go see the first blackbuck in his area of the Edwards Panteau; he saw nine animals that had been surplus zoo stock.

The first known Texas release came in 1932 in Kerr County (Jackson 1964), but Charles Schreiner (1968), owner of one today's most widely known exotics ranches, estimates that the releases on Richard Friedrich's Bear Creek Ranch, Kerr County, in 1939 and into the early 1940's have turned out to be the most significant in terms of numbers of exotics throughout Texas. Blackbuck were among Friedrich's original introductions. About 1935 Dr. William M. Mann of the Smithsonian Institution's National Zoological Park suggested to Friedrich that blackbuck would do well on his ranch (Stilwell

1955). Consequently, Friedrich got together with his friend Fred Stark, director of the San Antonio zoo, in 1937, and eventually 18 blackbuch arrived (Stilwell 1955). After an initial lag they thrived, and many of their offspring were given away to other ranches (Stilwell 1955, Schreiner 1968). A few years after the first release, additional bucks were introduced to add new blood, and by 1955 the herd had grown to about 300 blackbuck (Stilwell 1955).

After Eddie Richenbacker bought Bear Creek Ranch in the drought year of 1951, his son David worked to have the exotics pay their own way by instituting in Texas the now common practice of opening exotic hunting to paying guests and selling surplus animals for breeding (Schreiner 1968). This increased the interest in exotics and further dispersed the breeding stock. As more populations became established, more blackbuck went up for sale.

Since the first releases, Texas ranches have continued to provide outlets for some of the surplus from the San Antonio Zoological Gardens & Aquarium and sometimes from other zoos. The San Antonio zoo's close connection with the Bear Creek animals remains. About 10 years ago the breeding buck at San Antonio was traded for an adult male from Patio ranch, part of the former Bear Creek Ranch (Reed pers. comm.). Directly or indirectly, many of the Texas blackbuck are related to San Antonio stock.

The exact origin of the San Antonio blackbuck is unclear, but they evidently came in the 1930's during Fred Stark's directorship; before that time, the zoo concentrated on exhibiting native mammmals (DiSabato pers. comm.). Later the species was already established on Texas ranches. Presumably, a steady supply of offspring from blackbuck in other U. S. zoos — many, if not all, descended from stock imported into Europe from India (Effron *et al.* 1976) — would have been available to anyone not insisting on too many animals at once. Nevertheless, Stilwell (1955) writes of Friedrich importing his blackbuck in the late 1930's; this would seem to coincide with a shipment of 35 blackbuck from Pakistan to the United States in about 1940 (Bokhari 1970). Furthermore, Bokhari (1970) asserts that the 10 Hill Country blackbuck flown to Pakistan from Texas in 1970 were descendants of the animals in this

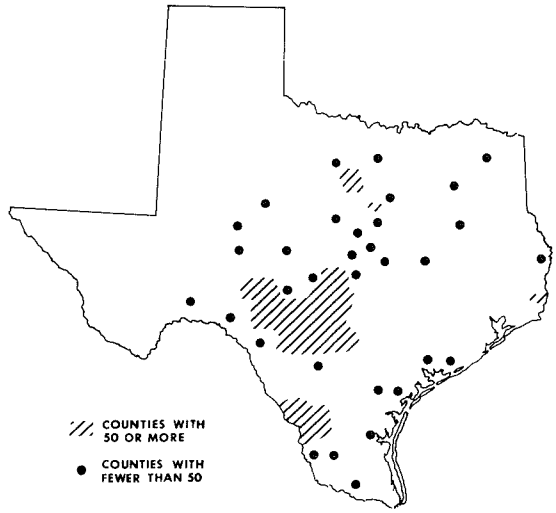


FIG. 1-5. Texas distribution of the blackbuck (adapted from Harmel 1975).

shipment. Therefore, both Friedrich's and Stark's blackbuck may have been the result of an arrangement to import in exchange for a share of the first offspring.

Typically, the concentration of blackbuck on a ranch continues to be in the pasture where the animals were originally placed. Unlike species such as axis deer, blackbuck are slow to move into new areas. When high densities — about one per 1.4 ha (one per 3.5 ac) in an observed case (Carpenter pers. comm.) — finally force dispersal, the pastures immediately adjoining are likely to keep most of the overflow. Densities of one blackbuck per 3 ha (one per 7-8 ac) are the highest observed in unhunted Hill Country populations which appear to have reached an equilibrium and from which the animals have periodic opportunities to move out if they choose. The number of blackbuck on Texas rangelands has risen dramatically. Ables and Ramsey (1974) discuss vegetation and similarities of climate when commenting on the success of exotics such as blackbuck on Texas ranches.

Although no official statistics were available, Stilwell (1955) guessed that in 1955 Texas had roughly 1,000 to 1,500 blackbuck. Growing numbers of privately owned exotics finally prompted a state-wide survey. The resulting census in 1963 showed 3,693 blackbuck on 35 ranches in 21 counties (Jackson 1964). A 1966 census revealed 4,125 blackbuck on 56 ranches in 33 counties (Ramsey 1969). By 1971 there were 5,470 blackbuck in 42 counties, with 84.5

percent of the animals living on the Edwards Plateau (Cook 1972). The latest census, 1974, estimated 7,339 blackbuck in 51 counties, with 80.7 percent of the blackbuck on the Edwards Plateau (Harmel 1975). Fig. 1-5 summarizes the 1974 Texas distribution by county. Blackbuck census figures may stop rising so steadily in the coming years as the number of suitable ranches without blackbuck decreases and as the present trend for ranches to be sold and cut up by developers increases.

Summary

Although blackbuck may have been known to Europeans since Alexander the Great invaded India in the fourth century B.C., the earliest detailed accounts of blackbuck are by the Moghul rulers who controlled India from the 16th to the 18th century A.D. The Moghuls were keen hunters as well as conscientious chroniclers. Their hunts decimated whatever wildlife populations they happened to find in an area, but the court rotated its center of acitivity. In between visits, the animals on favored hunting grounds were protected by game laws with penalties as severe as death. Thus, blackbuck and the other animals had time to recover. Lacking sophisticated equipment, the rural people were unable to make significant inroads into blackbuck populations.

Hunting blackbuck with cheetahs was a popular sport until both cheetahs and the large blackbuck herds disappeared before expanding cultivation and other human disturbance. Another sport was the matching of blackbuck in fights against each other. The emperor Jahangir kept a stud expressly to breed blackbuck for these matches and for catching wild bucks who could then also be used in the arena. In addition, tame blackbuck were used to decoy wild bucks within range of hunters.

The Moghuls' attention to detail shows up in their records of observations and their testing of common beliefs about the habits of animals. Similarly, this mentality has fostered an abundance of Indian miniatures executed with meticulous care. The numerous paintings showing collared bucks wearing tassels or bells are surely portraits of victors from the fighting arena. Indian poets and musicians have paid their own tributes to the blackbuck.

Another sphere in which the blackbuck has become part of India's cultural heritage is that of religion. The dark buck's white eye rings which suggest the moon in a night sky have linked the species to the moon god Chandra. By association with the types of plains country occupied by the waves of Aryan invaders, the blackbuck gained added religious significance. Consequently, local sentiment protects the blackbuck in some areas.

Present blackbuck populations in their native habitat are only a remnant of the teaming herds familiar to past generations. Nevertheless, there are still enough for determined action to secure the species for the future. According to one estimate, there were once 4 million blackbuck in India. However, the decline of the most common and most conspicuous plains game has been rapid. By the early 1900's sport hunting by the British with their modern arms had brought the first signs of decline, but remoter districts were still unaffected.

During the two world wars direct hunting pressure escalated. When the destructive storm of Indian Independence broke in 1947, there were some 80,000 blackbuck. Increasing habitat destruction continues the decrease and renders blackbuck populations vulnerable to local extinctions due to hunting. Today, almost no large wildlife species survive outside of sanctuaries, and yet overuse of the sanctuaries — poaching, grass gathering, wood cutting and grazing of domestic stock — endangers the blackbuck inside these refuges.

An estimated 10,000 blackbuck remain in India. Nepal has lost all but a token population. Pakistan was down to a few pairs plus an occasional migrant when the San Antonio Zoological Society helped the World Wildlife Fund solicit donations from Texas ranches. In 1970, 10 blackbuck were flown to Pakistan for restocking.

Large numbers of blackbuck now inhabit both the pampas of Argentina and the Hill Country of Texas. Since the first known release of blackbuck onto Texas rangeland in 1932, the Texas blackbuck population has climbed to a statewide estimate of more than 7,000. Population trends in the future will depend on the continued popularity and economic feasibility of the present game ranching system.

2

MORPHOLOGY/HABITAT

☐ The Indian blackbuck antelope is a handsome creature resembling a gazelle in comformation (see covers). Texas males average 75 cm (29 in) at the shoulder, females about 5 cm (2 in) shorter. In India blackbuck males measure up to 84 cm (33 in) (Meinertzhagen 1938, Krishnan 1972). Males weigh about 37 to 42 kg (82 to 92 lbs), females approximately 4 to 9 kg (10 to 20 lbs) less. (For a more detailed discussion of body measurements, see Chapter 6.)

Normal coloration

Coat color is one of this antelope's most striking features. The black coat characteristic of adult males gives the species the name "blackbuck." Females and young males, however, are an orange-tan. Fawns are brown at birth, passing through a lighter, creamy stage before developing the orange-tan at adolescence. Blackbuck of all ages have a sharply defined white patch around each eye and one on the chin. The chin patch sometimes extends onto the dorsal tip of the muzzle between the nostrils. A few individuals of both sexes have an ill-defined, whitish spot on the forehead. This only becomes apparent at close range. The ventral body surface and the inner surfaces of the legs are also white. All but the darkest males show a pale side streak. Most males remain tan on the dorsal surface of the neck, regardless of any change in general ground color (see front cover). The degree to which the tan hair between horns and ears lightens varies from one buck to another, approaching white in some dark bucks.

The ears of the males turn pale cream or white. Fawns have brown ears which are sometimes a lighter shade on the inside. In tan blackbuck the backs of the ears usually stay tan, but the hair on the inside changes to cream or white. As Fig. 2-1 illustrates, the inner ear hair grows along tracts rather than being dispersed

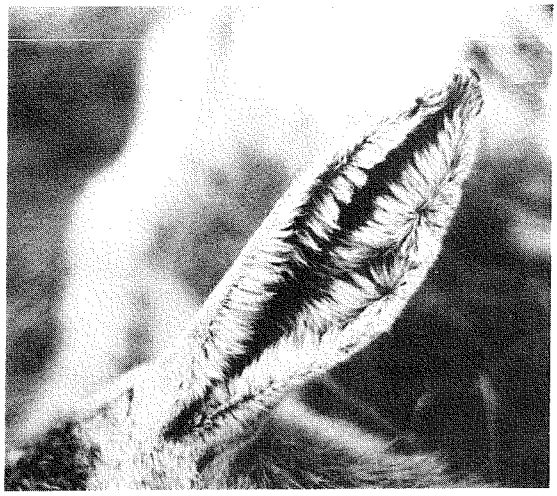


FIG. 2-1. Inner side of the ear showing distribution of hair along tracts.

evenly over the entire surface. Frequently, the outer ear is rimmed, often along the medial edge only, with dark hairs. Of 85 blackbuck of all ages and both sexes from one Texas pasture, 43 had a noticeable rim and 13 others had a slight rim which became evident only upon close inspection (Fig. 2-2). The rest had no dark ear rim.

Contrary to some descriptions (Blanford 1888-91, Lydekker 1893, 1907), the sheep-like muzzle is not completely haired. A small muffle area is exposed (Fig. 2-3).

A mark which distinguishes the blackbuck from all other ungulates commonly found in Texas pastures is a dark spot at the top front of each pastern (Fig. 2-4). Of 87 blackbuck in one pasture that were checked for these marks, only four fawns lacked any traces of them. Two more fawns showed none on the forelegs but had small, or small and faint, hoof spots on the hindlegs. All four marks were faint on one full term fetus and one fawn. One adult female had small, faint hind hoof spots even though her forelegs were marked normally. Since she was the only blackbuck older than a fawn that failed to exhibit fully darkened hoof spots, it may be that these spots generally develop later than the rest of the coat pattern. The front hoof spots are often larger with an upward tail, but they are not always as concentrated a black as the hind hoof spots.

Later chapters discuss specific aspects of normal coat color further as they become relevant. See the descriptions of displays in Chapter 4, the outline of field categories in Chapter 5, all of Chapter 7 and the sections on similarity with gazelles and on color cline in Chapter 8.

Albinism and melanism

Melanism is rare in blackbuck. One Indian case has been reported from Bhopal (Brander 1923) and none from Texas. By contrast, albinism is fairly common in India (Fig. 2-5), even though none has been observed in Texas. Recorded sightings go back at least as far as the 15th century. Jahangir, who took the throne in 1605, mentions having seen albino blackbuck in Hindustan (Jahangir 1909).

Since albinism occurs repeatedly in particular districts, recessive alleles for this trait are

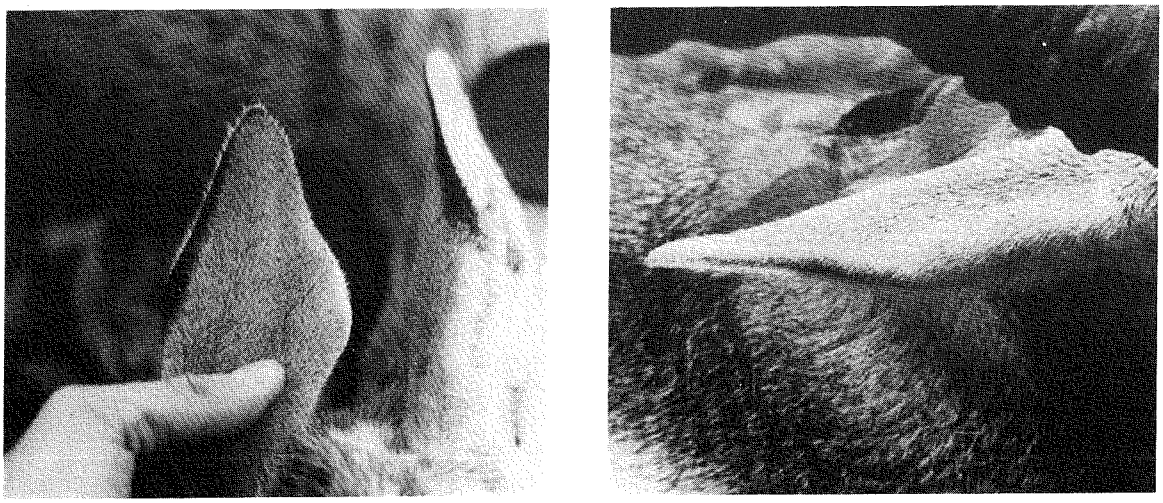


FIG. 2-2. Extreme development of ear rim (left) compared with slight rim (right).

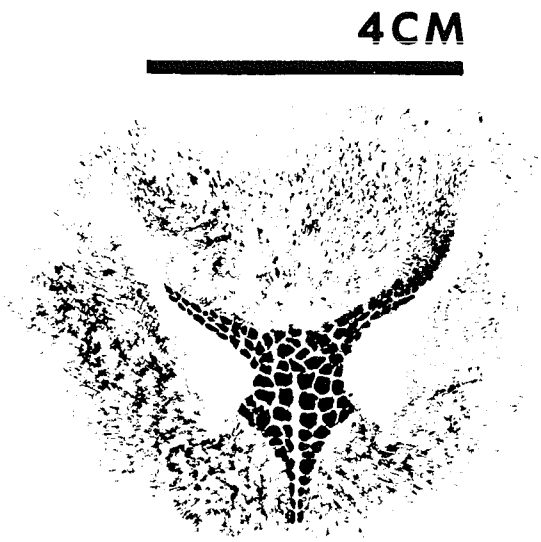


FIG. 2-3. Pattern of the exposed muffle area of the nose.

FIG. 2-4. Fore (upper) and hind (lower) hoof spots. Note that the corner of each is lateral to the long axis of the leg.

probably carried by the affected populations. Brander (1923) writes that sportsmen in the mid-1800's spoke of a "breed" of albino blackbuck living in Gujarat in a certain area. The tendency seems to persist, for a white buck was pulled down by a pair of wolves in Velavador Sanctuary, Bhavnager District, Gugarat, only a few years ago (Dharmakumarsinhji *in litt.*).

The most famous white blackbuck are probably those obtained from the wild during the 1800's by Sir Bhavsinhji, Maharaja of Bhavnagar (Gee 1969, Seshadri 1969, Dharmakumarsinhji *in litt.*). Starting in 1937 with albinos and partial albinos, the Maharaja of Kolhapur bred up a herd of 12 white animals; his son still has the group (Gee 1969).

Offspring of the late Maharaja of Bhavnagar's white blackbuck have been widely dispersed among Indian zoos. Besides descendants from early gifts, there is stock from the presentation by K. S. Dharmakumarsinhji of Bhavnagar to Sir Sayaji Maharaja Zoo, Baroda, and from his late brother's presentation to Ahmedabad Zoo (Dharmakumarsinhji *in litt.*).

The herd given many years ago by the late Maharaja to the Madras Zoo is now causing confusion among biologists because the zoo's guidebook of 1951 mistakenly announces that these white "deer" are descendants of English fallow deer acclimatized by a series of hybridizations (Seshadri 1969). In reporting a new parasite find, Ramanujachari and Alwar (1951)

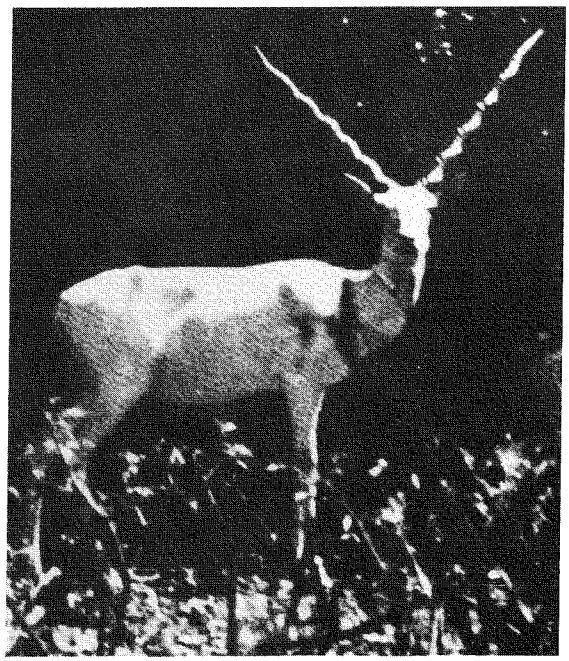


FIG. 2-5. Albino blackbuck in India. (Photograph courtesy K. S. Dharmakumarsinhji.)

tried to clarify the situation by describing the host as a cross between a blackbuck and a fallow deer, the hybrid having come from Bhavnagar. Sensing this to be impossible but not knowing what other choice to make, Yamaguti (1961) lists the parasite as having been recov-

FIG. 2-6. Interdigital area (opening by upper thumb) of foreleg held open. Note that center of hoof spot is higher than opening.

ered from both species. What may have misled the Madras Zoo into calling their white blackbuck "fallow deer" is the observation that white fallow deer are born tan. Fawns bred from white blackbuck that have black eyes are also a light, creamy tan or even the normal brown, turning white as they mature (Dharmakumarsinhji 1959).

White blackbuck with black eyes, which are sometimes sighted in India (Dharmakumarsinhji 1959), are not true albinos since total albinos lack even eye pigment. The snowy white buck on display until the early 1970's at the late Hon. Walter Rothschild's Tring museum sported horns and hooves of a waxy, pale yellow instead of the normal, blackish gray. If, in life, the eyes were pink, then his specimen was a true albino. Much earlier, Londoners visiting the Tower Menagerie had seen the albino buck pictured in Wright (1831).

Blackbuck which appear white were not always admired. During the rains of 1864, an old buck who was mangy and bedraggled enough to look white at a distance turned up near Allyghur after being driven from the Etah district because his unusual color was considered unlucky (Baldwin 1876).

Skin Glands

Blackbuck have several different kinds of exocrine glands. They may not, however, have functional glands in the "interdigital" area as is sometimes assumed. At the bottom of each hoof spot and reaching nearly to the top of the hooves is a pocket similar to that which in some deer is associated with an interdigital gland (Fig.2-6). Tests show that the cells lining this sparsely-haired infolding are of a type which might have secretory capacity. The tissue has a mixture of ceruminous glandular material and suboriferous glandular material (Robinson pers. comm.). Nevertheless, neither macroscopic nor microscopic examination has yielded any indication that a secretion is ever actually produced.

The blackbuck male is renowned for his preorbital glands which are true glands of a similar though much more highly developed structure. Hypertrophied ceruminous glands as

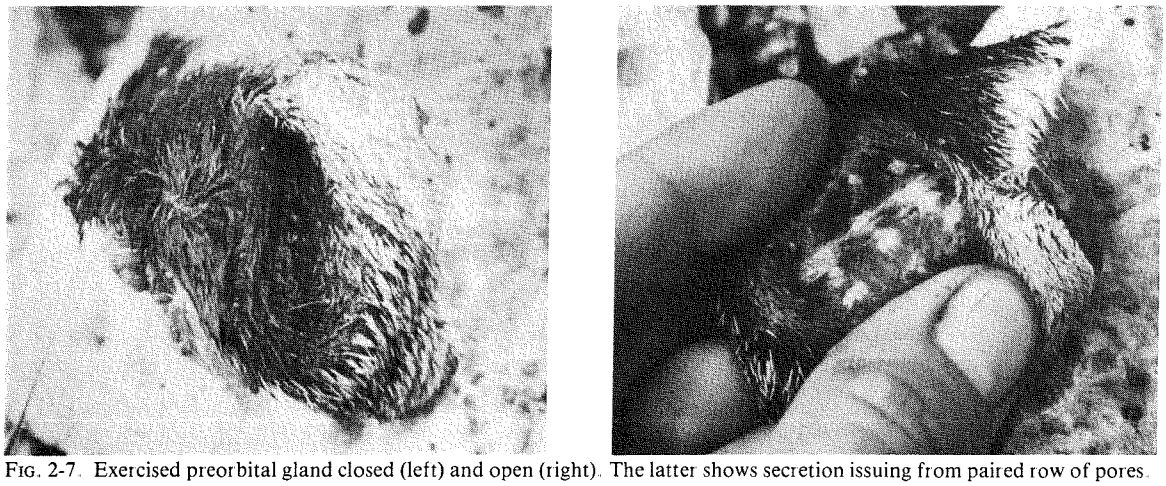


FIG. 2-7. Exercised preorbital gland closed (left) and open (right). The latter shows secretion issuing from paired row of pores.

FIG. 2-8. Tuft of long hairs which cover carpal gland in place (left) and spread aside to expose the short hairs with secretion granules underneath (right). Note that carpal gland is medial to center of carpal ("knee") joint.

well as suboriferous glandular material communicate with deep crypts in the surface epithelium; squamous epithelium carrying on its surface a prominent keratonized layer lines the crypts (Robinson pers. comm.). In subadults the preorbitals are gradually emphasized by black hair surrounding the opening. In males the glands then increase in size until they are conspicuous even when relaxed. Castrated males (Bennett 1836) and adult females have these glands, but they remain small and unused.

Bucks flare open the preorbital glands when they mark twigs or other protruding objects, when they thrash vegetation and when they go into the nose-up display described in Chapter 4. Unclosed, the lips of the gland form a ring. Pressure from the muscles circling the walnut-size mass expresses a pale paste from a paired row of pores down the center (Fig. 2-7). Lying on the skin surface, this secretion turns grayish. When the buck marks, the secretion disappears or, if the same spot is marked many times, changes to a clear or grayish film.

A gland of obscure function occurs just below and slightly to the inside of each carpal ("knee") joint (Fig. 2-8). Long hairs which cover it may help transfer some of a waxy, granular secretion to the bedding site whenever the animal lies down. A long hair tuft which emphasizes the site tends to be dark in adults even if the pigmented hair adjacent is tan — whether naturally or caused by wearing off of the dark hair tips. Even newborn fawns have two rows of short, stiff hairs running the length of the gland but lack the outer covering of long hairs and lack the secretion. The carpal glands consist of hair follicles plus hypertrophied sebaceous glands (ceruminous) underlain by extremely large piloerector muscles (Robinson pers. comm.).

Blackbuck of both sexes also have a pair of inguinal glands which secrete an oily paste (Fig. 2-9). Unless it has to do with olfactory recognition, the advantage of this gland, too, is undetermined. Each skin pocket is lined with a combination of ceruminous glands and sweat glands; the exterior layer is composed of ceruminous glands below which lie groups of altered sweat glands containing tall, columnar epithelium with much debris in the lumen of the glandular acini (Robinson pers. comm.).

All ages and both sexes carry one pair of teats to the inside of, and anterior to, the inguinal glands. These stay small and inconspicu-

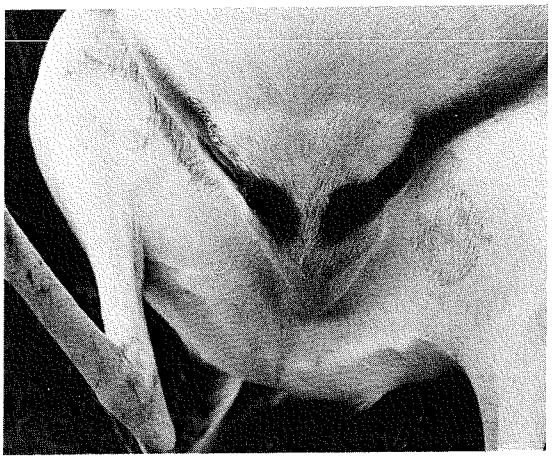


FIG. 2-9. Lactating adult female showing openings of the inguinal glands laterally above large teats. The udder is fully developed.

ous except in females of reproductive age who show mammary development (Fig. 2-9).

Horns

Only male blackbuck develop horns. (For a discussion of the rare cases of horned females, see Chapter 10.) These are both ringed and spiralled and diverge from the bases to form a tall "V" above the head.

The core of bone over which the horn sheath grows also spirals, but it shows no sign of rings. Unlike the horn cores of certain other bovids (Simmons pers. comm., Walther pers. comm.), the cores of blackbuck horns end well below the tip of the sheath. The intervening space is filled with additional highly vascularized tissue, like that which covers the core.

The degree of divergence from the horn bases can vary considerably even in the same district. This holds true in India (Brander 1923) as well as in Texas. Lydekker (1893) estimates that horns of equal lenghts can vary anywhere from 178 to 508 mm (7 to 20 in) in tip-to-tip distance. On Rowland Ward's trophy list, which gives spreads for 37 pairs of blackbuck horns from 648 to 737 mm (25.5 to 29 in) long, the minimum spread is 355 mm (14 in) for horns of 606 mm (26.25 in) and the maximum is 705 mm (27.75 in) for horns of 673 mm (26.5 in) (Dollman and Burlace 1935). Wylie (in Simmonds *et al.* 1923) gives an isolated case of a spread of 800 mm (31.5 in) for a head measuring 724 mm (28.5 in) on the right and 713 mm (28.12 in) on the left. Texas examples show a range of 25 to 45 degrees for spreads that look narrow and 55 to 70 degrees for spreads that look wide.

During adolescence the outer sheath of horn in at least certain bovids is forced upward by the horn growing beneath; it then dries and begins to split away (Buffon and Ogilby *in* Iftikhar *et al.* 1937). Hall (1936) noted a similar case in an immature blackbuck, although this was probably a subadult since the outer casings were 400 mm (15.75 in) and 419 mm (16.5 in) long, respectively, for the right and left horn. When Hall (1936) requested information on additional cases, only one — for a buck that may have been an adult — was reported. However, the comments published raised to five the recognized number of similar cases in adult nilgai bulls (Hall 1936, Iftikhar *et al.* 1937). In Texas this condition has frequently occurred in grown nilgai (Fig. 2-10) but has never been noted in any blackbuck age class. Alternatively, it has been suggested that, at least in domestic cattle, such instances are induced by poor nutrition (Thomas pers. comm.).

Compared to the size of the body, the blackbuck's horns look very large. Measurements can be misleading, however, because different measuring techniques produce different results. For example, Brander (1923) had a pair of tightly twisted horns which was 597 mm (23.5 in) when measured straight and 749 mm (29.5 in) when measured "round curves," whereas a pair of horns with a more open spiral was 502 mm (19.75 in) straight and 787 mm (31 in) "round curves." At least three different measuring techniques are in use. A straight, frontal measurement from base to tip is the most common. Many authors specify which method they employ. Some people prefer to measure along the curve because the straight-line method underestimates the amount of horn grown by a buck with an open spiral in relation to one with average twisting and the latter over one with a straight spiral. The difficulty is that, without any definite keel to follow, it is not clear where to place the tape so that the measurement will be reproducible on the same buck and comparable to lengths from other bucks. The modification in which a tape is wound around the horn and pulled taut has the same disadvantages. In the Texas study straight measurements were used throughout.

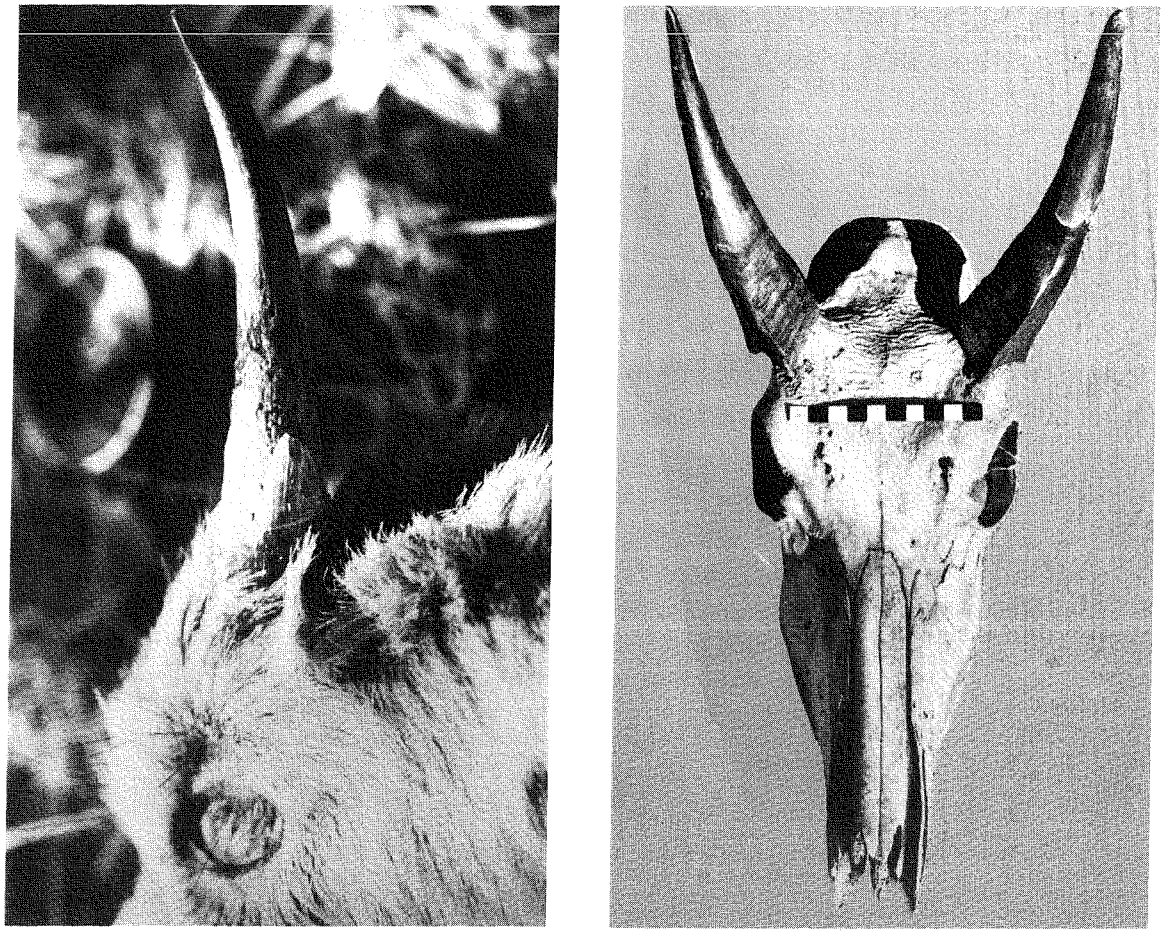


FIG. 2-10. Normal case of first horn sheath splitting away from the new horn growing underneath in adolescent blackbuck (left) compared with cap of horn over one tip of sheath in adult nilgai. Blackbuck rarely retain caps like that on this nilgai.

Horn lengths of adult blackbuck in Texas are commonly in the 368 to 432 mm (14.5 to 17 in) range. Among the Texas adults sampled — all sampling without selecting for horn characteristics — the longest was 584 mm (23 in). This was the only pair over 495 mm (19.5 in). First class Texas trophies are 508 mm (20 in) or more, but there are very few such bucks. A cumulative Texas trophy list has only 13 heads in this category (Temple 1976). The longest horns on this list reach 590 mm (23.25 in) on one side and not quite 584 mm (23 in) on the other.

In India horn length and body size increase from south to north and from east to west (Brander 1923, Dharmakumarsinhji and Gaikwad 1958, Krishnan 1972). Bucks reach a large body size in central India but do not usually attain maximum horn development except in northwestern India (Forsyth 1871). The Texas figures suggest the horn lengths characteristic for southern India. Horns there seldom reach the 432 to 508 mm (17 to 20 in) range (Elliot *in* Jerdon 1874, Percy 1849, Aflalo 1904, Stockley 1928) and 559 mm (22 in) is a decided rarity. In central India horns are intermediate in length (Andrews *in* Simmonds *et al.* 1923, Stockley 1928). Here, horns longer than 559 mm (22 in) are good, and 635 mm (25 in) is exceptional (Stockley 1928).

Length records came from northwestern India. Longest, owned by the Maharaja of Jind, is a 806 mm (31.75 in, straight measure) head with a 724 mm (28.5 in) spread (Dollman and Burlace 1935). Others of 762 mm (30 in) or more are one of 781 mm (30.75 in, probably straight measure) shot by Gangootri Shikar on Mohun Pass, one of 775 mm (30.5 in, straight measure) owned by Lt. Col. J. MacRae-Gilstrap and a pair of horns at least 762 mm (30

TABLE 2-1. TROPHY HORN LENGTH RANGES BY REGION. LENGTHS (STRAIGHT MEASURE) IN MILLIMETERS WITH INCHES IN PARENTHESES.

REGION		RANGE			
		Fair	Good	Exceptional	Maximum
INDIA	Northwestern	559 mm (22 in)	635 mm (25 in)	711 mm (28 in)	813 mm (32 in)
	Central	482 mm (19 in)	533 mm (21 in)	635 mm and over (25 in and over)	
	Southern	406 mm (16 in)	508 mm (20 in)	559 mm and over (22 in and over)	
	Average	457 mm (18 in)	584 mm (23 in)	711 mm (28 in)	813 mm (32 in)
TEXAS		381 mm (15 in)	508 mm (20 in)	584 mm and over (23 in and over)	

in) long bagged by Col. C. J. Garstin near Ferozepore (Sclater *in* Strong 1907, Dollman and Burlace 1935). These lengths rival the height of the animal itself.

Really long trophies of 711 mm (28 in) and more gradually became harder and harder to find, so that by the start of the 1900's, even in the best areas, horns of 584 mm to 660 mm (23 to 26 in) were being praised as ". . . very fair trophies for present day shooting." (G. 1909, p. 494). Anything under the 508 to 610 mm (20 to 24 in) range was small (Aflalo 1904, Rokeby in Simmonds *et al.* 1923), with heads of 584 to 610 mm (23 to 24 in) not uncommon (Jerdon 1874). The maximum range hunters could reasonably expect was 635 to 711 mm (25 to 28 in) (Percy 1894, Aflalo 1904). Rowland Ward's list has only two trophies of 737 to 762 mm (29 to 30 mm) (Dollman and Burlace 1935).

Although particularly good heads were available, they were not as plentiful within the population as record figures might suggest. Baldwin (1876) liked a long pair of horns as much as the next sportsman, and yet, of more than 200 bucks that he shot, only one had horns as long as 635 mm (25 in). With the increasing difficulty in finding long horns, the accepted standards for Indian trophies shifted. Over 457 mm (18 in) became "shootable," 610 mm (24 in) was "very good" and any mention of 737 mm (29 in) or more was regarded with suspicion (Jerdon 1874, Sterndale 1884, Stebbing 1911). Table 2-1 summarizes the regional variation in the trophy categories. For other topics relating to blackbuck horns, see Chapters 5, 6, 8 and 10.

General physiography of habitat

To understand a species, one must understand what kinds of places it is adapted to inhabit. What are the significant physical and biological characteristics of its habitat? With this knowledge, one can begin to evaluate different segments of the population. One can also make predictions about the success of animals introduced into new areas. For instance, knowing that blackbuck reach their best development in the dry, plains regions of the northwestern Indian subcontinent, should one be surprised that blackbuck do poorly in moist parts of east Texas? Awareness of potential problems allow the manager to counteract adverse effects. The more information management has at its disposal, the more effectively it can approach its goals. General physiography of the Indian subcontinent is summarized in Appendix B.

Distribution within native habitat

Blackbuck were once dispersed locally throughout India wherever conditions were favorable (Jerdon 1874) — neither too wet a climate, too steep a grade nor too closed a canopy (Fig 1-4). Although essentially a plains species, they also frequented river banks and even found their way onto the long-grass islands in river valleys (Percy 1894, Lydekker 1907). Seemingly capricious absence of blackbuck from some areas which appear ideal (Percy 1894, Lydekker 1907) may be due to past hunting or recent clearing; blackbuck are slow colonizers. Assertions that they extended into Persia (Wright 1831) are erroneous. Lictenstein's 1814 work on the genus *Antilope* helped dispel the idea that

blackbuck occur in Africa; this misconception had arisen because of the similiarity of addax horns, which have an open spiral and weak annulations (Sclater and Thomas 1897-98).

In peninsular India blackbuck inhabited the scrub and grassland of the palteau country. On the black cotton soils of the Deccan basalt they lived among scattered clumps of *Acacia* and *Ziziphus* plus other small trees and shrubs (Prater 1971). The blackbuck would penetrate into the more open parts of predominantly deciduous forest formed by stunted teak, bamboos and various other small trees (Prater 1971). Noting that the blackbuck is the major large mammalian species seen in settled areas, Forsyth (1871) theorizes that the species has penetrated certain areas by following the clearing activities of immigrant peoples. Schaller (1967) considers that slash-and-burn cultivation opened to blackbuck the moist deciduous forests of central India (including the region which became Kanha National Park), eastern India and similar parts. Balckbuck frequented the cotton fields so typical of cultivated districts within the black cotton soil type (Prater 1971). Other animals characteristic of the open parts of the peninsular plateaus are chinkara, jungle cat, common fox, Indian wolf, common mongoose, palm squirrels, hares and various field rats and mice (Prater 1971).

Southward from the vicinity of Surat, jungle and dense forest make the Malabar coast between the western mountains and the sea unsuitable for blackbuck; no populations established themselves there (Blanford 1888-91). East of the mountains, blackbuck may not have extended quite as far south as Cape Cormorin. Visiting the cape in the late 13th century, Marco Polo found "Komari" to be a forested province (Polo 1953). The southernmost blackbuck locality actually known to Blanford (1888-91) was Point Calimere.

As might be expected for a distributional limit, the sandy strip which comprises Point Calimere is not ideal. Extending west along the coast from near Point Calimere, the Cauvery delta becomes marshy (Chatterjee 1973). Farther inland, the plains of Mysore are exposed to the southwest monsoon (Chatterjee 1973). Point Calimere is vulnerable to the cyclones which the northeastern monsoon often throws against the coast (Daniel 1967). Such storms with their attendant flooding are said to cause heavy mortality among the blackbuck in Point Calimere Sanctuary (Stacey *in* Daniel 1967). The animals, as observed by Daniel (1967) when grazing was sparse, looked in good condition. However, Jerdon (1874) considers that since the grass there was green all year, the blackbuck tended to be in soft condition, as evidenced by this being one of at least three locations where blackbuck could be run down successfully by greyhounds. Although tried repeatedly in many parts of India, blackbuck coursing was notably unsuccessful unless the ground was heavy with sand or mud (Baldwin 1976). Being out of condition was known to compound the blackbuck's disadvantage of poor footing (Baldwin 1876).

In the drier, western zone of the Indo-Ganga plains and on west into the Thar Desert, blackbuck congregated in large herds (Prater 1971, Prakash 1975). They abounded as far west as the Indus and, by way of the Chenab, the Indus tributary Jhelum (Percy 1894). Along with nilgai and porcupine, blackbuck is a characteristic species of the central plains (Sarkar 1975). Blackbuck roamed north into the *terai* (northern limit of the Indo-Ganga plains) but did not cross the narrow *bhabar* (a dry stretch of gravel and boulders which separates the *terai* from the foothills of the Himalayas) into the areas where snow is common (Blanford 1888-91, Spillett and Tamang 1966).

Blackbuck are not found in the humid areas of Bengal where xerophytic plants are replaced by mangoes, figs and palms under a moist climate similar to that of the coastal peninsula (Prater 1971). Neither can they live in the swamps and forests of the Ganges delta (Blanford 1888-91). Only a few were found within Bengal's former limits north of the Ganges (Jerdon 1874), but there were many in Midnapore on the plains near the coast in lower Bengal (Blanford 1888-91). In part of the country between the Ganges and the Jumna, blackbuck were plentiful (Jerdon 1874). Blanford (1888-91) indicates that some occurred as far east as lower Assam, and Sterndale (1884) heard they extended into Assam.

Texas distribution

More than 80 percent of the blackbuck in Texas live in the "Hill Country" (Harmel 1975). The

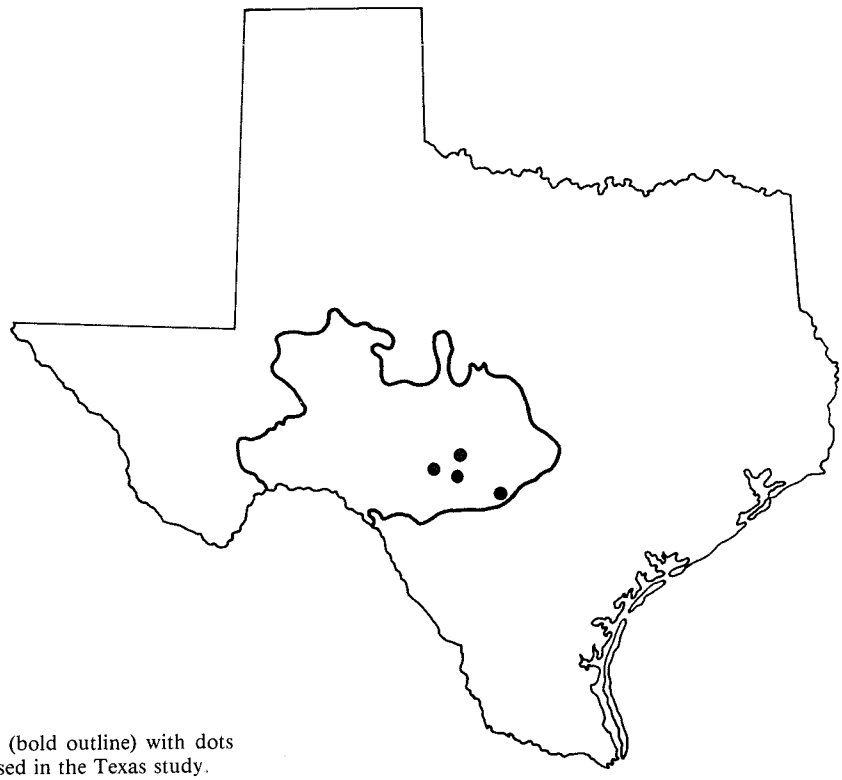


FIG. 2-11. The Edwards Plateau (bold outline) with dots locating the four main ranches used in the Texas study.

major portion of this region is the Edwards Plateau (outlined in Fig. 2-11) where relatively flat limestone beds of the Edwards series, laid down during the Cretaceous and deeply dissected during the next 75 million years, were left raised above the coastal plain to the east by Pliocene faulting along the Balcones Escarpment (Udden *et al.* 1916, Sellards *et al.* 1932).

In any given year, precipitation may vary greatly from the mean of 64 cm (25 in) calculated for the Edwards Plateau (Carr 1969). Annual precipitation for Gillespie County, near the area of most concentrated blackbuck study, registered a low of 28 cm (11 in) in 1956 and a high of 123 cm (48 in) in 1880 (Allison *et al.* 1975). In most years, potential evaporation exceeds precipitation, and droughts are characteristic (Carr 1969). The number of days a year with no appreciable precipitation averages 271 (Orton 1971). Severe windstorms and measureable snow are rare, but there are occasional hail or ice storms.

Increased thunderstorm activity and cooler air moving in from the north contribute to the precipitation peaks in May and September (Carr 1969). In contrast to the mean precipitation range of 3.3 to 6.9 cm (1.3 to 2.7 in) for the other months, May averages 9.0 cm (3.5 in) and September averages 7.9 cm (3.1 in) (Carr 1969). Flooding is common during the fall peak. Summers are dry (Allison *et al.* 1975).

During the summer the difference between the warmer days and cooler nights is particularly noticeable (Allison *et al.* 1975). Daily temperatures fluctuate widely, while mean annual temperatures remain fairly constant (Carr 1969). For the Edwards Plateau mean annual temperature is 19°C (67°F) with a January mean of 9°C (49°F) and a July mean of 28°C (83°F) (Carr 1969). Temperatures can be high during any season (Whitney 1916). On the average, temperatures reach 32°C (90°F) or above on 99 days a year (Orton 1971). During some nights winter lows approach −18°C (0°F).

Averaged over the whole year, relative humidity is fairly uniform but, like temperature, it fluctuates considerably during the day. Mean average humidity at 0600 is 79 percent but at 1200 it is 52 percent and by 1800 it has dropped to 47 percent. (Allison *et al* 1975).

Wind speed averages 14 km/h (9 mph) (Orton 1971). The prevailing direction is southerly except when disrupted by polar air masses which are common in winter (Allison *et al.*

1975). These "northers" seldom last more than 2 or 3 days (Whitney 1916). In contrast to the heavy showers of spring and fall (Carr 1969), winter precipitation is mainly in the form of light rain or drizzle (Allison *et al* 1975). Mornings are frequently overcast, particularly during the winter (Allison *et al.* 1975). During the present study, skies usually cleared by 1000 and afternoons were then sunny and warmer.

In Gillespie County, the frost-free period averages 219 days (Allison *et al.* 1975). The last spring frost observed in 1973 on any of the study sites was a light frost on 18 May. This was more than a month later than the last spring frost observed in 1974. The first fall frost in 1973 was a heavy frost the night of 15-16 November.

In the southeastern portion of the Edwards Plateau concentrated on for this study, vegetative cover is predominantly live oak, ashe juniper and mesquite in the brush areas and Texas wintergrass, threeawns, Texas grama, hairy tridens, curlymesquite, buffalograss, Indian grass and bluestems in the open.

The area's major industry is cattle, sheep and goat ranching. The conspicuous native ungualtes are white-tailed deer and, in some places, javelina. Ungulates from other countries are commonly stocked and hunted. The most abundant exotics are blackbuck antelope, nilgai antelope, axis deer, fallow deer, sika deer, aoudad sheep and mouflon sheep or mouflon crosses (Young 1973).

Fig. 2-11 locates the ranches within the Edwards Plateau used extensively by the blackbuck project. Of the pastures visited on a regular basis, three were greater than 200 ha (500 ac) and three were 20 to 200 ha (50 to 500 ac). The small pastures relied upon most heavily were roughly 40 ha (100 ac) in size. The large pastures for which material has been analyzed in detail exceeded 300 ha (740 ac), the largest being about 445 ha (1,100 ac). Pens and traps less than 20 ha (50 ac) are excluded from the discussion of small pastures.

There was no disturbance from hunting on any of the major study sites. All the pastures used were inhabited by both native and exotic game. In addition, one of the large pastures was stocked with cattle on a rotation basis. There is evidence of some past brush clearing over most of the area. Except for two of the small pastures which may have been farmed in the past, grazing is probably the only type of use this land has had.

There are no streams or rivers available to the animals in any of the areas where observations were concentrated. Ground water pumped up by windmills runs into tanks, troughs or ponds. On one site there is a manmade pond which catches rain water. Wells tapping the Edwards limestone formation are a common source of water both for humans and for animals on the Edwards Plateau (Taylor *et al.* 1966).

Summary

The present study was undertaken to obtain informatin needed for the management of blackbuck populations. Indian blackbuck antelope are gazelle-like in conformation and stand about 70 to 75 cm (27 to 29 in) at the shoulder. Some bucks from the more northern parts of India grow as tall as 84 cm (33 in). Females and young males are mainly tan above and white beneath, whereas many adult males approach black on the major pigmented areas. A white patch surrounds the eye, the chin and — in dark males — the ear. Although albinism has never been reported in Texas, this condition is fairly common in certain Indian districts.

Skin glands include preorbital glands, carpal glands and inguinal glands. No evidence of secretion was found in either the fore or the hind interdigital areas.

Only male blackbuck develop horns. The width of spread between the tips varies in any locality. Length, however, has characteristic ranges for different regions. In India increasing length progresses in a cline from south to north and from east to west. Texas measurements seem closest to those for southern India.

The blackbuck thrives best in places where the vegetation is not too dense, the climate is not too moist, the temperature does not fall too low and the topography is not too rugged. Therefore, the blackbuck's maximum known distribution in India covers the northern, central and southern plains and open woodlands but is limited by the thick jungles of the west coast, the wet portions of Bengal and Assam and the cold, steep slopes of the Himalayas. In Texas, habitat characteristics have a similar effect on the success of the species in the different ecological zones of the state.

3

SOCIAL ORGANIZATION

☐ Before assessing any population, a manager must know how it is organized. It is also important to know how the animlas make transitions from one social category to another.

Social grouping

Both male and female blackbuck may be seen in single-sex groups, in mixed groups, in pseudo-harems or alone. None of these social units exhibit migratory behavior either in India (Baldwin 1876, Sterndale 1884) or in Texas. However, single adult bucks and, rarely, adult females occassionally immigrate from a nearby pasture. One such buck was observed to emigrate again after almost a year.

A common misconception, at least in Texas, is that territorial bucks keep harems. They do not. Instead, female groups make a large, daily circuit, and territorial males join the females as they pass through the territories. Since the circuit may remain the same for several weeks at a time, some of the females may be sighted many times with the same bucks at approximately the same time of day. A territorial male together with a female or a female group may be considered a pseudo-harem. When one or more subadult males or an adult male without a territory (i.e., a bachelor) joins one or more of the females above the fawn stage, this constitutes a mixed group. Mixed groups and pseudo-harems are often hard to distinguish unless one knows the individual bucks involved.

Pseudo-harems and mixed groups

When evaluating groups which contain both male members older than adolescents and female members older than fawns, one question which arises is whether they are truly mixed groups or whether they are merely pseudo-harems, the result of a territorial male tem-

porarily joining with a female group while it is within his boundaries. A pseudo-harem usually has only one mature, dark male and no other adult or subadult bucks, but even these criteria allow two major errors. First, some medium to large groups with more than one dark buck are examples of one territorial buck entering the vanguard of a female group before the neighboring buck has quit displaying to those females who have not yet crossed his border. The larger the female group, the greater the chance it will overlap territories as it moves. Second, while no truly tan males were identified as territorial during the Texas study, some dark bucks certainly were bachelors. Since occasionally a tan buck was alone with a female or a female group, some of the sightings of a dark male alone with a female or a female group may not represent pseudo-harems at all.

Thus Table 3-1, compiled from summer data from 2 consecutive years on an unhunted population of about 125 ± 15 blackbuck in a 327 ha (807 ac) Texas pasture, lumps mixed groups with pseudo-harems, since not all of the males were individually known. This category of Table 3-1 is heavily weighted in favor of pseudo-harems, however. Only a small number of groups (32 out of 290) could not be classified as mixed group or pseudo-harem on the basis of the above criteria, and only 72 groups were either mixed groups or cases of multiple territorial males with one female group. Of the 258 groups that could be classified, 72 percent were indicated as pseudo-harems. The proportion is highest for groups of two animals (90 percent; N = 57); many of these cases are, indeed, known to have been ones in which a territorial male was displaying to a doe. Then the proportion decreases: 72 percent (N = 92) for smaller groups of 2 to 9 animals, 65 percent (N = 51) for medium sized groups of 10 to 19 animals and 53 percent (N = 30) for groups of 20 to 29. Although 80 percent of the groups with 30 to 39 animals had only one mature, dark buck, only 10 of the groups in this size range could be classified; thus the high percentage may be due to sampling error. The proportion for groups of 40 or more drops to 67 percent (N = 18).

Consistent with the large proportion of groups that seem to have been pseudo-harems, 10 is the average size both for the male-plus-female groups and for the all-female groups shown in Table 3-1. Clearly, a fuller understanding of male-female groups requires a separate study including qualitative as well as quantitative data on all the bucks observed.

TABLE 3-1. COMPOSITION OF SUMMER (1971 AND 1972) GROUP SIZES FOR A LARGE POPULATION IN A LARGE PASTURE. FOR EACH MONTH SIGHTINGS ARE GIVEN AS PERCENT OF THE TOTAL NUMBER OF GROUPS SIGHTED THAT MONTH.

	Solitary	Group					
No. in Group	1	2	3 - 9	10 - 19	20 - 29	30 - 80	Totals
Male Groups (max. = 27)							
June	46.4	12.3	28.2	7.7	5.4	0	220
July	71.0	7.5	17.8	2.3	1.4	0	214
August	65.0	12.7	17.7	4.5	0	0	220
No. of groups	397	71	139	32	15	0	654
No. of members	397	142	738	458	347	0	2,082
Pseudo-Harems (max. = 74) and Mixed Groups (max. = 61)							
June		12.3	35.2	20.5	13.1	18.8	122
July		34.5	31.0	18.4	9.2	6.9	87
August		26.2	45.0	16.2	8.8	3.8	80
No. of groups		66	106	55	31	32	290
No. of members		132	547	767	763	655	2,864
Female Groups (max. = 80)							
June	31.1	14.6	30.1	8.7	7.8	7.8	103
July	31.4	15.3	33.1	10.5	5.6	4.0	124
August	33.8	10.3	36.8	13.2	1.5	4.4	68
No. of groups	94	41	97	31	16	16	295
No. of members	94	82	477	415	399	667	2,134

Like female groups, mixed groups can be quite large. In the large Texas pasture with about 125 ± 15 blackbuck, the largest female group observed had 80 females and young and the largest mixed group had 61 bucks, females and young. Because of the way territorial bucks can monopolize available space in a small pasture and keep females away from the bachelors, mixed groups are primarily a large-pasture phenomenon in Texas.

Mixed herds in India must have represented a significant proportion of the population at the time when blackbuck still inhabited so much of the plains country. Blanford (1888-91) reported single herds including all sex and age classes occasionally numbered several thousand. The largest herds Jerdon (1874, p. 277) saw were in the Deccan where there were sometimes several thousand blackbuck "...with black bucks in proportion." Jerdon (1874) also observed up to a maximum range of 50 to 60 females with a single buck. From his description, these were particularly large female herds in which a territorial buck was active. Synthesizing material from a number of authors, Lydekker (1907) sets the size of female herds at 10 to 30 and sometimes up to 50. This, then, would suggest the average size of pseudoharems in India at the turn of the century. Baldwin (1876) saw mixed herds of 200 to 300 where he was quartered in India, but he never saw large congregations of 1,000 or more like those that sportsmen in other provinces had met. Stockley (1928) saw herds of more than 500 in the Punjab and of more than 1,000 in Bikanir, although these are maximum figures. In a particular case he mentions (Stockley *in* Simmonds *et al.* 1923) there were some 70 blackbuck, at least 6 of them mature bucks. The maximum reported were the occasional herds of 8,000 to 10,000 blackbuck of which Scott told Jerdon (1874). Lydekker (1907) finds it hard to credit such extremes.

Writing about part of the Thar Desert in Rajasthan, Prakash (1975) reports that up to 500 blackbuck could still be seen together in the wild. He estimates the normal herd size as 20 to 30. The photograph he uses shows more than 30 bucks in one herd; a large majority are adults. Whether there were any females with this herd is uncertain since not all the animals are shown.

With females as well as nonterritorial males showing the same general pattern of daily activity and living in the same places, except where territorial bucks exclude other males, these two types of animals are bound to come in contact with each other. When the males do not try to court the females, there is nothing to disrupt the association. Indeed, where there are large numbers of animals, it would be difficult for the bachelors and the females to remain segregated. In addition, the large numbers can make it impossible for a territorial buck to prevent the association. As with the all-male groups, the composition seems to be fortuitous. The particular combinations of animals may be even more ephemeral than for the bachelor associations, since outbursts of displaying by males disrupts the cohesiveness of mixed groups.

No specific leaders were distinguished. Instead, the predominant direction and activity of the group was determined by "voting" (Walther 1973), a process by which animals show different directions or activities with some vacillation until the group conforms to what has been adopted by a major portion.

Single-sex groups

In comparing the composition of male groups, male-female groups and female groups in a Texas population, Table 3-1 demonstrates several trends. The decrease in number of large, all-male groups as the summer progresses indicates a decrease in sociability among the bucks. This correlates with an increase in activity among the bucks as fall approaches. The same phenomenon may also contribute to the decrease in number of large male-female groups. Female groups remained relatively constant in size. The apparent decrease is primarily a function of having had to terminate August observations after 3 weeks instead of the full 4.

Another trend is that females were seen in very large groups more often than were bucks. All-male groups of every size from 2 through 27 were observed. Thirty seemed to be the upper limit, despite there being more than 30 bucks in the pasture. This may be a species-specific limit. In India Stockley (1928) noted bachelor associations of up to 20 males, and Elliot (*in* Jerdon 1874, p. 277) summarizes his impressions of the maximum size when he describes

the bachelor groups he saw in India as ". . . sometimes containing as many as 30 individuals of different ages."

The maximum size recorded for a female group, 80, was probably about as large as was possible in the large Texas population simply because of the available numbers of females, fawns and adolescent bucks. Whether there is any limit to the size of the female groups other than obvious constraints of space, topography, extent of grazing areas and available numbers could, therefore, not be determined. The fact that female groups are larger is probably also related to the fact that there are more potential members for the female groups in a blackbuck population. Male groups have adult, subadult and adolescent bucks; female groups have not only adult, subadult and adolescent females but also adolescent bucks and older fawns of both sexes.

In spite of the difference in maximum sizes, both bachelor groups and female groups are usually only small to medium in size. All-male groups averaged six bucks, and 82 percent of the all-male groups had fewer than 10 animals. In 28 percent of the groups, there were only two animals. Female groups were not much bigger; the average size was 10 with 68 percent having fewer than 10. Again, a significant proportion, 20 percent, had only two animals.

Lone blackbuck

Although, technically, single animals are not groups, it would be unsatisfactory not to consider lone individuals when discussing grouping. Most solitary males are territorial. There is no season during which some adult males are not territorial, but fewest tend to be in summer. Nevertheless, the proportion of sightings of lone bucks remains high throughout the summer. (Sightings are facilitated by the conspicuousness of bucks in open country.) Texas sightings indicate 19 percent lone bucks as compared with 81 percent in groups. Figures for both years are almost identical.

Only 4 percent females were sighted alone. Both because female groups commonly include older fawns and adolescent bucks as well as females and because a lone doe is less conspicuous than a lone buck, the female figure is less reliable as an estimate of the proportion of lone females out of all the females in the pasture. However, the actual proportion probably is lower than for males.

Females with neonate fawns constitute the majority of sightings of lone does. These females return to female groups within a few days of parturition. In a few weeks, the fawn is also part of the group so the doe no longer must separate from the group for nursing. Bucks, on the other hand, frequent their territories for months, and so one would expect to have many more sightings for each territorial buck than for each lone doe. What the data in Table 3-1 do indicate is that the number of lone females during any given time period studied is lower than the number of lone bucks.

Female blackbuck

Similarities and differences between female and male groups are not limited to size characteristics. Each type of association deserves to be examined separately.

Group stability and population size

In pastures with only a few females, these females stay together. As group size approaches 10, a strong tendency develops to split into smaller units for the middle of the day, grouping together again by evening. In smaller pastures where there are fewer places the animals can go and be out of sight contact, this trend is less clear.

Once a large pasture has a large population, big grazing groups that form in the afternoon may not always contain the same animals, even though the herds can be quite predictable as to size and time of arrival at a certain spot. To see whether the smaller units retain their identity or whether the females are assorted differently each time the herds split would require more individually known females than have been available to date. Considering the ties that remained between a female with an Austrian herd and her 2 year-old and 3 year-old daughters even after the birth of another fawn (Schmied 1973), subunits based on familial ties may persist for a few years, at least in small to medium size populations.

The large herds of females grow or decrease by the addition or subtraction of the smaller units. By late afternoon when the largest groups form, most of the females have already come together at least into medium sized groups. As they graze farther and farther into the open, two of these will often come closer and closer until they are one.

Leadership

Whether large or small, the group is not necessarily led by the animal farthest to the front. This seems particularly true if an older fawn, an adolescent or even a subadult doe is at the head of the group. As the animals move, now one member and now another is in front. Brander (1923) believed that in blackbuck herds and in all other herds of antelope or deer an old doe is the leader. Eighteen years of buck stalking in India convinced C. (1902) that the common, small groups of blackbuck females with a male in attendance are always led by a doe. Among the females at the Austrian experiment station, Schmied (1973) noted that for years it was the original doe of the pair with which the blackbuck herd had been established that the others followed to and from the feeding places. In his captive group, Walther (1959-60) noted a rank order among the females, but it was not particularly apparent whether the alpha female performed any leading function.

A rank order can indicate that the animals know each other individually. This would be quite possible in small to medium sized groups that are together for weeks or months. Here, lasting leadership-followership relations like those Schmied (1973) reports can be formed. However, if the membership of smaller groups in large populations changes with the splitting of the larger herds each day, then leadership in the smaller groups may resemble that in the large herds. Voting (Walther 1973), as described for the mixed herds, seems to determine the predominant activity and direction of the large female herds as well.

When smaller groups remain intact in the large herds, these subunits may tend to vote in blocks and, thus, help to carry the herd one way or another. In this case, any leadership position within a smaller group could indirectly become a leadership position within the larger group. The presence of many such indirect leaders could also facilitate the eventually splitting which is observed to break apart the larger groups. Alternatively, the simple voting of individuals could carry some animals one way and some another.

Recruitment of adults

Recruitment into small populations indicates that the females in a small to medium sized group distinguish between members and nonmembers of the group. An adult doe and a subadult doe from one group were trapped and released in an enclosure with a grown buck and a group of 15 females and young. For the first day or two, the other females chased the newcomers (M. Ahrens pers. comm.). After about a week, the chasing had subsided but the two still kept apart from the group much of the time. A month later, both were full members of the group. Introduction of another strange adult doe approximately 3 weeks after the others produced the same pattern of chasing (M. Ahrens pers. comm.) followed by integration with the rest. The original females were able to single out the new releases as different. This strongly suggests individual recognition.

Socialization of fawns

When fawns become members of female groups, they are also integrated gradually. Their pattern of activity has to shift from one in which they lie out for all but a few brief care periods to one in which long intervals of grazing alternate with their periods of rest.

Initial contact with group

Often before the end of its first week, a fawn has had contact with members of a female group as the group has grazed into the fawn's vicinity. The mother displays to or butts away any females and young who come close to the neonate. The older fawns are often first to approach and also most persistent; they are the first whose approaches the dam will tolerate. In the beginning, however, this strong attraction is not mutual. Not until after its first week does the fawn show interest in other fawns. By this time, the bond with its mother is already well established so that the contact with other antelope does not interfere.

General bond vs. "peer companions"

The new interest which starts to manifest itself with brief approaches at 1 week of age is more apparent by 2 weeks when the fawns begin to spar together and to lie together. This general bond among fawns is different from the "companion effect" (Mungall 1977) which develops at 2 to 3 weeks of age after the fawns have had a chance for contact and ceases to be conspicuous after 2 to 3.5 months once the fawns are well integrated into the female groups. The companion effect insures a fawn close contact with a conspecific during the transition phase between lying out and full group membership without requiring strong ties to the mother which would have to be broken before the dam next gives birth. As Land, a former wildlife biologist on the Y. O. Ranch, describes them, "companions" are fawns who do just about everything together except nurse. These animals, "peer companions," spend more time together than with any other blackbuck. Unless there are no fawns suitably close in age, the two companions are within only a few days in age. Companions can be of the same or of different sex. As explained in Chapter 6, companions could easily be mistaken for twins.

Final integration

For the first 2 months, the fawns wander about, nibble on bits of vegetation and then lie down. They begin staying with the female group after reaching 1 month of age. As the group moves beyond them, they rise and catch up and the cycle repeats itself. By 6 to 8 weeks, the fawns are spending about as much time grazing as the adult females are. Necropsy of one fawn younger than 2 months and one fawn older than 2 months confirmed that the neonate was still dependent on its mother's milk while the older fawn was supporting itself on vegetation. After 3 months nursing attempts are rare. The activity pattern of the fawns has gradually conformed to that of the older animals.

As they spend less and less time lying outside of the group's general rest periods, the bond between peer companions seems to weaken; the observed companion effect is no longer as marked, even though the animals involved still sometimes seek each other when they are ready to lie down. Now when subunits form within the group, these are associations of adolescents or subadults rather than predictable combinations of two particular individuals.

Social rank of females and young

Fawns are inferior to any older blackbuck and so, when present, fawns form the most inferior age class within the female groups. The older animals pay little attention to them, however, unless one gets in the path of a buck displaying to a doe, is in the way of another blackbuck trying to reach the same feeding spot or mounts and butts and runs with its agemates so close to the older antelope that the group is disrupted. Although not every female of any given age class is the equal of every other female in that class, it is still true that both adolescent and subadult females are inferior to all older blackbuck.

On the other hand, adolescent males sometimes prove to be equal or superior to both adolescent and older females if the adolescent bucks are determined in their efforts. Thus, adolescent males can make even an adult doe move ahead or give place at a feeding site. Such activity attracts the attention of resident bucks when female groups cross into territories, and the adolescent males eventually leave the female groups altogether as the territorial males increasingly single them out as objects of aggressive displays and chasing.

Bachelor males and bachelor associations

Any nonterritorial male older than a fawn and no longer living primarily in association with any female blackbuck is considered a bachelor. A buck who has just given up a territory may remain alone for 1 to 3 weeks, but bachelors usually range with other bachelors.

Bachelor males do not form rigidly cohesive groups, but merely chance assemblages in different combinations during the day's activities. Any buck is free to wander away or to lag behind at any time. The mild rise in frequency of agonistic exchanges at the end of resting periods or when most of the grazing animals switch to moving ahead does tend to coordinate activity and, thus, to keep the animals together. However, there is no leader who calls or herds the others.

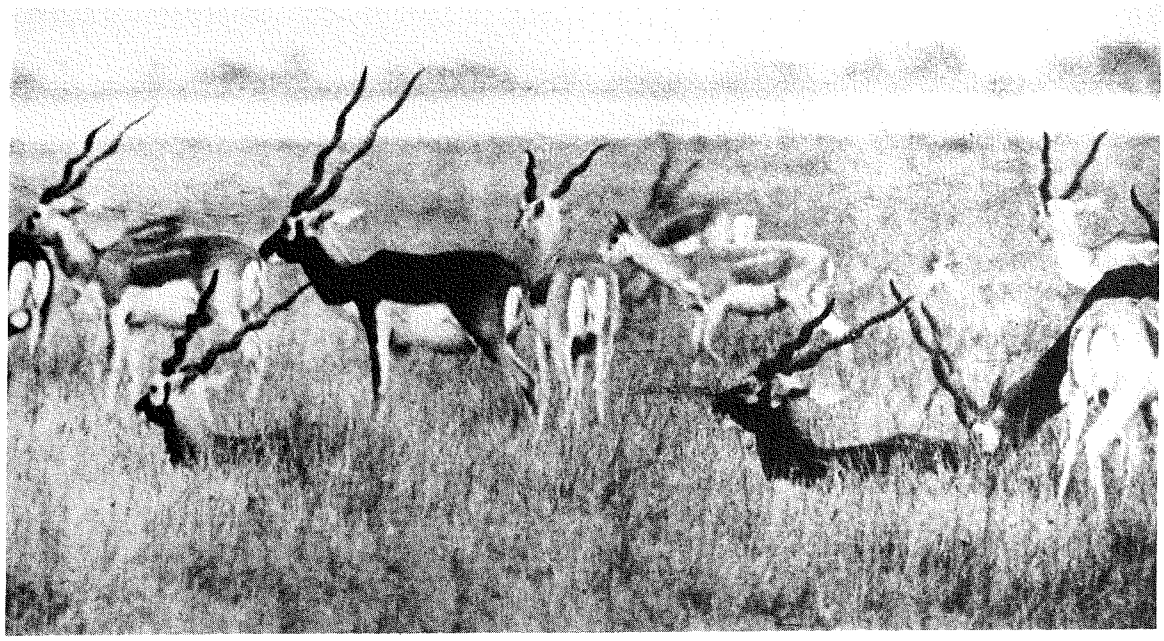


FIG. 3-1. Bachelor association in India demonstrating that, as in Texas, adults as well as subadult and adolescent males are included. (Photograph courtesy K. S. Dharmakumarsinhji.)

Subgroups

Usually there are animals of different age classes in any bachelor association of four or more animals. As Fig. 3-1 shows, immature males are not necessarily the major component. In even the largest groups more than half the members can be adults.

Mixture of age classes has several ramifications. Primarily, it creates subgroups. The like-aged animals tend to graze nearer each other and to lie together. In small pastures or where there are only a few nonterritorial bucks in a population, these subgroups may have fairly stable membership and may even develop a hierarchy. The adult bucks have a passive leadership role. As long as the others stay with the older bucks, the whole unit remains intact. If the younger animals do not rise with the adults after a lying period, if they graze in a different direction or if they fail to keep up, they are left behind. They may rejoin the adult bucks at any time, but the adults will not actively seek to rejoin them. Thus, when bachelor associations split it is usually along age lines.

"Bachelor companions"

Analogous to the companions found among fawns and probably as an extension of this same phenomenon, two bucks originating from the same female herd and becoming bachelors at about the same time can act as companions also (Mungall 1977). Since they stay together, this pair can form the core of a subunit, either fortuitous or stable, within a bachelor association. If, on the other hand, they are forced out of the female herd in a pasture where there are no other bachelors, they become the bachelor group. When an adult buck subsequently becomes a bachelor, the two companions may join him. The adult buck who has just recently become a bachelor will not seek their company, but he will accept it. Two bachelor companions may also be joined by younger bucks reaching bachelor status later. No matter how the bachelor group eventually grows, bachelor companions can still be distinguished as a subgroup.

Continually in each other's company from the time they become bachelors at about 6 months to 1 year of age, the bachelor companions develop a dominant-subordinate relationship. This is true whether they live among other bachelors or not. Although horn growth appears equal for both, at approximately 15 months of age the superior animal may have surpassed his companion in weight, including the characteristic male thickening of the neck. After reaching maturity at about 2 to 2.5 years, the superior will grow a pepper-colored coat for the fall, whereas the inferior's coat will show

much less of the dark color other than on face and legs. (For more on this plus other aspects of color differences, see Chapter 7.) In both cases of this type followed in pastures rather than in small pens, the superior companion made a determined effort to become territorial during his first fall as a mature animal, whereas neither inferior companion made any such attempt. One young adult was successful; the other failed after trying for several days.

Manipulation with a penned bachelor group indicated that an inferior bachelor does not undergo irreversible changes that would prevent him from assuming a dominant role at some future time. The question then becomes whether, in an actual situation, an inferior companion will become more assertive after his superior companion has left the bachelor group. Presumably, this might be the case. During the increased fall activity in one pasture, an adult who had been the inferior companion to an adult who had become territorial the previous spring made a bid for a territory himself, albeit unsuccessfully. However, there are pressures which tend to perpetuate an individual's inferior status once it becomes well established. Where small bachelor groups have stable membership and a rank hierarchy based on individual recognition rather than merely on sex, age class and condition, an inferior companion may be routinely dominated by several other bucks, even younger ones. When the superior companion leaves, the legacy of domination continues to suppress the inferior's initiative. Being independent from the beginning, males who come alone to join the bachelor group have a better chance than does an inferior companion to develop to maximum potential in minimum time. Rather than becoming territorial themselves, inferior companions are more likely to give the bachelor group continuity under normal conditions and to insure the population against a loss of breeding capacity should there be heavy losses among the territorial bucks.

Effects of adults in groups of mixed ages

Adult bucks in a bachelor association are not very tolerant of youngsters who display or spar or chase each other in the immediate vicinity. Like territorial bucks among the females and adolescent males inside their territories, adult bucks among the bachelors approach a persisting disturbance among the younger bachelors usually causing the immature bucks to disband and switch to submissive grazing or to move away. If they are slow to react to the approach, the youngsters are often chased a short distance. When immature bucks do not react, the adult starts into a nose-lifted display, adding components as necessary until the full form is expressed. Reaching the offender, the adult thrashes his horns down over the other's haunches or lunges at him with presented horns. By now, the offender is sure to be aware of the adult and runs away.

This interference from the adults develops an inhibitory influence on aggressive actions by the younger bucks. Similarly, in smaller, more stable bachelor groups that develop hierarchies, the less dominant bucks experience the same interference and show the same inhibition in the presence of more dominant adults. Thus, the adult who breaks up sparring or displaying among the younger bucks may not be the closest adult buck to the disturbance but, instead, one of the more dominant of the adults who are near. The effect of this inhibition is a more peaceful group and a more cohesive group. The frequent minor violations of individual distance or the even more frequent mild displays which cause an animal to rise, displace it from a particular grazing spot or make it move ahead are usually kept from developing into prolonged fights or from creating further disruptions.

Contact of bachelors with territorial bucks or with females

When bachelors wander into a territory and their presence is being tolerated by the owner, then the territorial buck, as the most dominant blackbuck present, takes precedence over all the bachelors. If he takes no action to stop an outburst among the bachelors, then no buck does. Once the territorial buck starts displaying to any of the bachelors, he usually ends by chasing away all of them.

The inhibitory influence of adult bucks on younger bucks seems to vanish, however, when females appear. Sometimes bucks just run at the females and chase them. More often the bucks assume the nose-lifted display, the younger bachelors usually assuming an incomplete form, and approach the females more slowly.

Their persistent close approaches set a doe running quickly. A bachelor then gives chase, with other bucks trying to cut in between if they are not off chasing other females themselves. The bachelor association evaporates. The only time such a melee was ever observed to result in true copulation was on one occasion when a newly adult bachelor chased a doe into a territory. The owner charged over and fought with the intruder while a subadult bachelor entered and bred the doe after a brief session in close courtship. Had that part of the territory been accessible to the remaining bachelors during the fight, rather than being beyond another territory swiftly cleared of invaders by the owner, the subadult would have had the usual competition from the rest of the bachelors and a successful courtship would have been impossible.

When hard pressed, females flee the bachelors and get away. They may simply outrun and outmaneuver the bachelors, or they may run into a territory where the owner chases off the bachelors. Predictably he goes after one of the older bachelors first. This bachelor runs to one or another of its agemates. Then they, plus any bachelors in between or close by, file away together. If the territorial buck keeps on after the same animal, the file splits into two or three and the buck who is followed may or may not veer to follow one of his compatriots again. Once the territorial buck lets his objects go, he returns and goes after another bachelor in the same way. In this way, the older bucks take the brunt of the territorial buck's action. This spares the younger bachelors, unless they are slow to scatter or leave the area. It also focuses the territorial buck's attention on the males that pose the more effective threat to his position: those most likely to take over a territory and those most likely to have both the maturity and the restraint to court a doe successfully, given the opportunity.

Transition to bachelor status

Assuming bachelor status benefits the adolescent buck, since the older bachelors are the preferred objects of chasing by territorial bucks and since adults in bachelor associations of mixed ages keep fights short and have a depressant effect on aggressive interactions generally. Even during the transition period, the adolescent may not be the addressee in many more aggressive encounters than when living in a female group. First, it is mainly the quality of the interactions that changes. Among the bachelors, it is predominantly those closest to the newcomer's age who threaten him. However, the newcomer can also spar with them; his sharp spike-like horns, which keep slipping out of lock, insure him a measure of success. Contrary to his situation in the female group, the adolescent male in bachelor company is singled out less and less as time passes, and he is chased less once he ceases to be a special object of the bachelor's aggressive approaches. When a youngster finally loses his inclination to run back to join the females when there is an alarm, he becomes a full-fledged bachelor.

Considering that a buck's first experience with bachelor males is usually some threat or blow or chase, it is hardly surprising that young males with compatible male company in the female group make the transition to bachelor status much later than adolescent males with no male agemates at hand. One buck with three female agemates left at 6 months. When the next fawns came in this same pasture, there were three males and one female. These males did not leave until the eldest was 1 year old, although they had had previous brief encounters with some of the bachelors. If there is a territorial buck in the area, an adolescent male will eventually separate from the females, even if he has neither male agemates nor other bachelors to join. As might be expected, however, having a bachelor group already in the pasture and having it nearby facilitates the transition.

Both harassment and decreasing opportunity to spar with others drive the adolescent from the female group. Once the male develops horns, his female agemates avoid sparring with him. The gregariousness of the species and the greater chance to spar lead him to join other males. Also, a territorial buck is much more prompt in stopping any sparring among youngsters within a female group inside his territory than adult bachelors are about interrupting fights among the younger bachelors. A youngster who has switched to living among bachelors still gets displayed to and still is chased, but he can also lock horns with other bucks and playfully go through the motions which later will be vital to his success in serious fights.

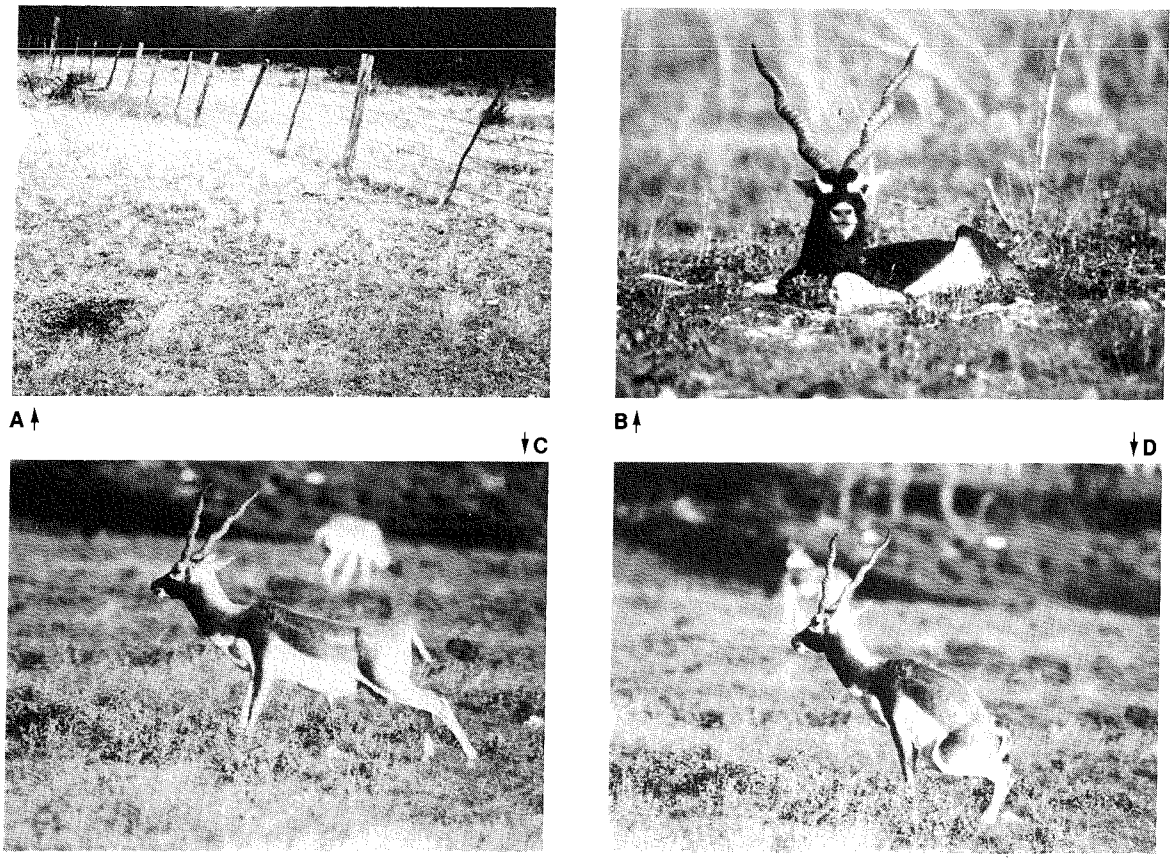


FIG. 3-2. Dung piles and associated displays: (A) dung pile at lower left of picture, (B) territorial buck lying on one of his dung piles, (C) male in urination display at dung pile, (D) male in defecation display at dung pile.

Territorial bucks

There are several ways a buck can become territorial. Simplest is when a buck finds himself in an area inhabited by female blackbuck only. Here he can concentrate his activity and set up his dung piles (Fig. 3-2A) without interference. These dung piles are focal points of his territory and become his primary resting places. Similarly, a buck may happen upon an unoccupied area near occupied territories. Here again, the newcomer merely moves in and takes over old dung piles or establishes new ones. Bachelors sometimes try to secure a territory by excluding the other males from part of the range commonly frequented by the bachelor association. Some subadult or newly adult bucks just drop out of a bachelor association as it passes a favorable stretch and localize their activity there. Occasionally, a buck will win a territory by defeating a territorial buck.

Except in the rare cases where there are no other bucks in the vicinity, a new buck will come into conflict with other males sooner or later. When he does, he must prove himself equal or abandon his claim. If the place he has chosen is part of another buck's territory, the established buck will keep chasing the newcomer away until he either stands and fights or stops coming back. During the days or weeks the ground is in dispute, the established owner will also show increased frequencies of scraping, urination and defecation at his dung piles.

As fall approaches, the general level of aggressive interactions among the bucks increases. This is when newly adult bucks of 2.5 or 3 years are most likely to gain their first territories. Ordinarily, a territorial buck wins all the fights within his territory against any buck and outside his territory if against a bachelor. If a bachelor wins against a territorial male, however, the apparent psychological link

between "place" and "win" turns the bachelor into a territorial buck at that place. This holds true even if the bachelor did not initiate the fight and was not trying to take over a territory at the time the fight started. The deciding factor as to which buck among the present bachelors will be next to gain a territory is not age alone, but a combination of age and such psychosomatic properties as aggressiveness and physical health.

Characteristics of blackbuck territories

Although blackbuck often use wooded areas with an open canopy for grazing, resting or traveling, bucks select open, grassy areas for territories. These flat expanses of short to mid grasses are the sort female herds favor for late afternoon and early morning grazing. Prime areas are seldom vacant at any time of year. Dirt roads, ditches or strips of pavement sometimes cross the territories. Use of such features as boundaries occurs only when they are well above or below the adjacent ground surface (Fig. 3-3).

Territories range in size between a minimum limit of 1 ha (2.5 ac) and a maximum limit of 20 ha (49.4 ac). The averages observed in two large Texas pastures were 2.0 ha (4.9 ac; N = 17) and 3.3 ha (8.2 ac; N = 10) with the territories generally smaller where the comparative lack of natural boundaries made defense more difficult. (For further comments on sizes, see Chapter 12). Territories are compact rather than elongate. Besides facilitating defense, this makes it easier for a buck to stay with a doe during a complete courtship. A territory is usually adjacent to at least one or two other territories. Common boundaries are strips some 15 to 20 m (50 to 65 ft) in width. Both natural discontinuities such as cliffs, stands of trees and deep or wide rocky water courses and man-made obstacles such as fences may be taken as borders on one or more sides (Fig. 3-3)

Each territory has at least one dung pile (Fig. 3-2A; Fig. 3-3). One or more is often situated well inside the territory with another or others near the edge. All give the buck excellent visibility when he uses them as resting places (Fig. 3-2B). Those dung piles at the periphery are close to where the buck often leaves or enters, either when beginning or ending interactions with other blackbuck or when going to or from points outside the territory for food or water. Bucks in general check the olfactory condition of any dung piles they come across. Newly territorial bucks seem to know their own dung piles by smell, whereas well-established bucks also recognize visually the arrangement of such landmarks as rocks on the fringes of the dung pile (Cary 1976b).

The owner within his territory

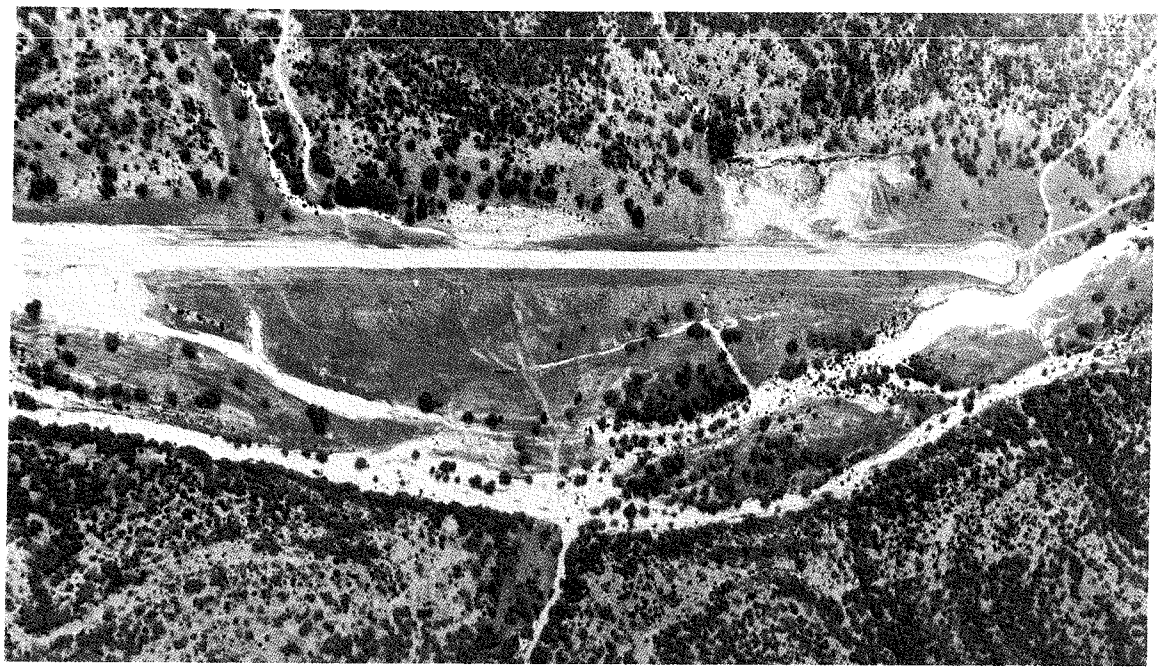
When alone in his territory the buck spends the majority of his time either grazing or lying at one of his dung piles. Rising from one, he begins grazing. Then he lies down again, frequenlty on a different dung pile. All the while he is alert for the approach of other blackbuck. These socially inactive periods are interspersed with periods when females or bachelors wander through the area.

As soon as females appear, the territorial buck approaches one or more in the nose-lifted display and may try to block their exit from his territory. If he finds a sexually receptive doe, close courtship may follow. Otherwise, the females all continue on their way in spite of any blocking efforts of the buck. Bachelor bucks are usually chased away from the territory. If there are no females in view, however, the bachelors may be permitted to stay as long as they graze quietly without drawing attention to themselves by creating disturbances.

Brief border encounters between neighbors are frequent. They consist of an exchange of displays or of a ritualized fight with much displaying and only a few clashes. After the encounter, both bucks usually graze back to the closest of their dung piles and assume the striking urination and defecation postures typical of all blackbuck males (Fig. 3-2C and D). Used here or after chasing off bachelors, these postures probably have an advertising display function of the dynamic optical type (Hediger 1949). Since it is the territories on which breeding takes place, rival bucks must be effectively warned off and excluded.

The role of territorial neighbors

Neighbors help define the boundaries of a buck's territory and furnish proper targets for his aggressive tendencies. Since bucks are replaced one at a time with the new occupant



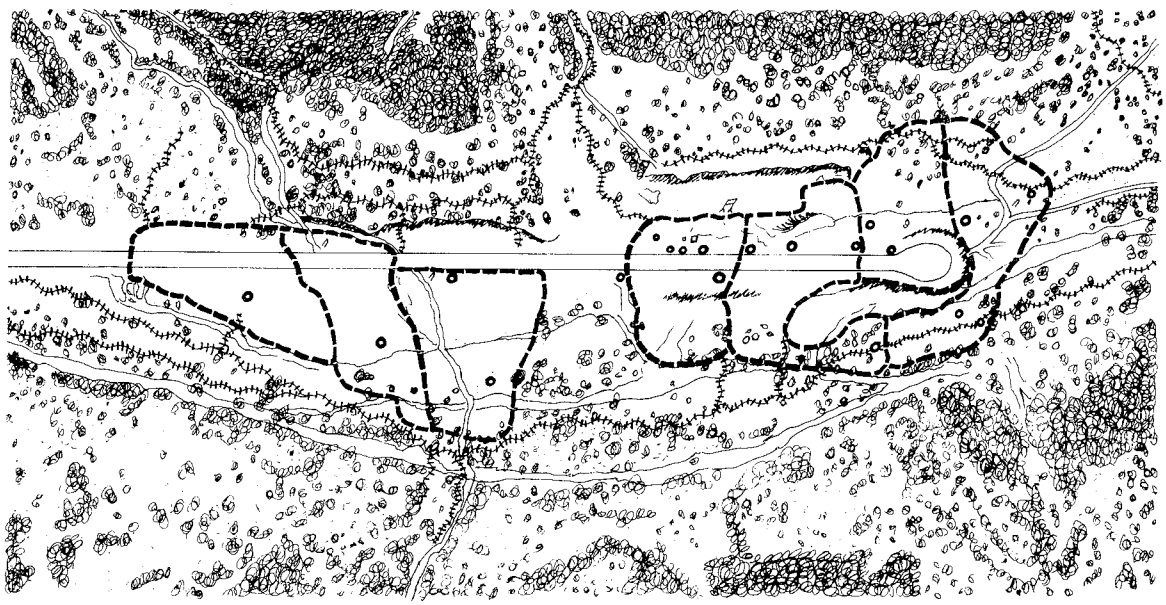


FIG. 3-3. Aerial photograph and outline map of a valley showing vegetation and topographical features in relation to paths, territory boundaries and dung piles.

surrounded by old neighbors, borders change little from one occupant to the next.

If deprived of even bachelor adult or subadult male company, a buck maintains a core area but wanders extensively and stays with the females longer as they move along. If there are other adult or subadult males in a pasture but only one territorial buck, the buck's borders are defined. Without the daily border encounters, however, such a buck may leave his territory briefly in the afternoon and seek out bachelors if none have yet come close enough for interaction that day. Finding the bachelors, the territorial buck displays and may chase them if they are slow to withdraw.

Time and place considerations

As already indicated, during the day brief absences from a territory are normal. Some interactions take bucks beyond their borders. Shade, water or sufficient food often must be sought elsewhere. Disturbances are likely to cause flight. The owners are usually back by 1400 or 1500 hours at the latest and ready for the female groups that are coming out into the large openings. Owners in the final phases of territoriality, however, may not return until dark and may only make short visits to their territories during the day. These visits become shorter and fewer until the buck stops coming altogether.

Bucks can assume or give up a territory at any time of year. A few bucks even remain territorial for more than a year. Nevertheless, the Hill Country bucks that are most regular in their habits tend to take up territories in late summer or early fall and hold them into spring. Then they leave to spend most of the summer in bachelor associations before resuming territories again in late summer or early fall.

Fig. 3-3 shows how the open floor of a valley in one Texas pasture was divided into territories at the time of preliminary observations in November 1973. Fig. 3-4 diagrams the ownership changes documented during one year beginning the following January. As this series demonstrates, bucks tend to return to the same territories (Fig. 3-4, note bucks SX and IH). A buck who fails to regain a territory he formerly held may take up residence close by (Fig. 3-4, note bucks IH and TI). Some blackbuck make a brief attempt at holding a territory again in another place not long after having left (Fig. 3-4, buck SX) or lost a well established holding. Bucks may also expand into an adjacent area (Fig. 3-4, buck FX).

Summary

Both male and female blackbuck may be either in single-sex groups, in mixed groups, in pseudo-harems or alone. Blackbuck are gregarious; the majority of animals sighted during the Texas study were in groups. Even territories of adult bucks are fairly small and are held more effectively when clustered together with adjoining boundaries.

Blackbuck do not keep harems. Instead, female groups make a large, daily circuit, and territorial males join the females as they pass through territories. Since the circuit may remain the same for several weeks at a time, some of the same females may be sighted many times with the same buck at approximately the same time of day even though this buck does not stay with them throughout the day. A territorial male together with a female or a female group may be considered a pseudo-harem.

Ordinarily, a female does not remain alone except in the vicinity of her neonate fawn who is in the lying-out phase. Fawns are normally seen only alone, with the mother or with female groups. After 2 to 3 weeks, the "companion effect" manifests itself as pairs of fawns tend to form individualized bonds. Fawns gradually become members of the female groups as the youngsters spend less time lying-out. Both males and females then grow up in the female groups.

Adolescent females remain in the female groups, but adolescent males are ultimately forced out by increasing harrassment from territorial bucks. The adolescent males then join other nonterritorial males in all-male groups. Also called bachelor associations, these include many adult as well as immature males.

Two bucks who make the transition to bachelor status together can act as "bachelor companions." Being continually in each other's company, a dominant-subordinate relationship develops. Even after the superior companion becomes territorial, the inferior companion retains a subordinate rank within the bachelor association if there is a stable hierarchy.

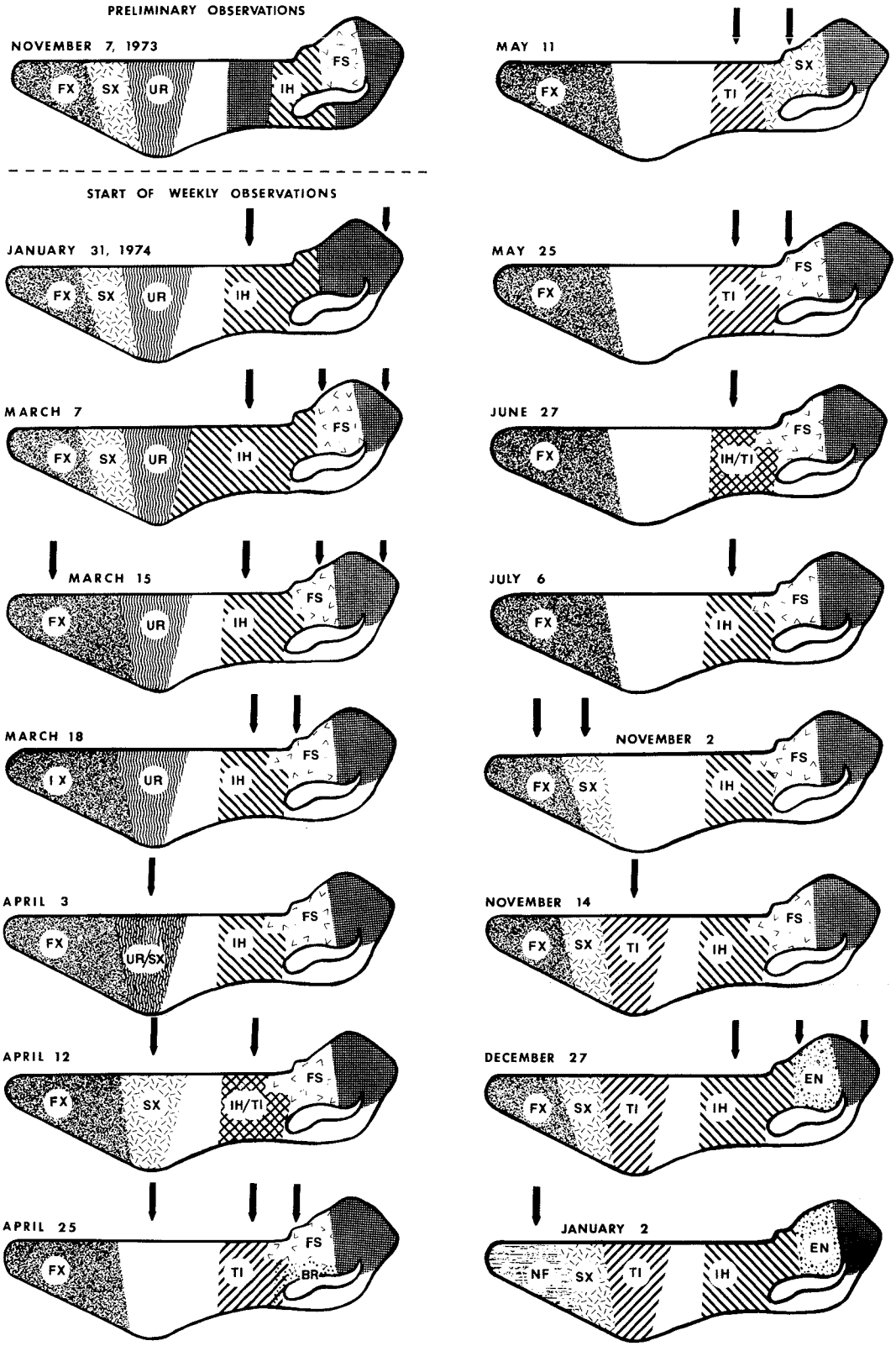


FIG. 3-4. Diagrammatic maps giving territory changes along a valley, shown in Fig. 3-3, during one year. Blank areas were unoccupied. The two-letter designations identify known bucks who owned the territories. Where there is no designation, the owner, or succession of owners, did not include any of the known bucks.

4

BEHAVIOR

☐ In order to understand more complex behavior, one must first be aware of general behavior patterns. Using this background, one can then appreciate the blackbuck's more involved patterns like play, fighting, courtship and territoriality.

Tool Activities

Tool activities (Lorenz 1966) are behavior patterns which occur as basic units within more complex sequences. Locomotor patterns and general postures are standard types of tool activities.

Locomotion

Blackbuck pace more readily than they trot. For chasing and flight they gallop. More striking than their ordinary gaits, however, are their jumps. Even though reluctant to hop over anything but low objects like stones, limbs or dirt paths, blackbuck exhibit four distinct types of jumps (Fig. 4-1). Three of these — "stotting," "*Finten*" and "steep jumps" — are not intentionally used to cross obstacles; probably this reflects the open aspect of their native plains.

When playing or alarmed by something which is not running close upon their heels, blackbuck frequenlty spring into the air in a succession of stiff-legged jumps called stotting (Fig. 4-1B). After stotting in play, fawns fling up their heels and exhibit an exaggerated trot for a few steps before they slow their speed.

Finten (Walther 1959-60) is a kind of jumping back and forth which can appear in both play and conflict situations. When *Finten* occurs, it is usually in a situation in which two immature bucks are sparring and one performs these jumps with head low as if the closeness of his partner were somewhat frightening (Fig. 4-1C). The buck performing *Finten* is likely to be the younger or the inferior animal.

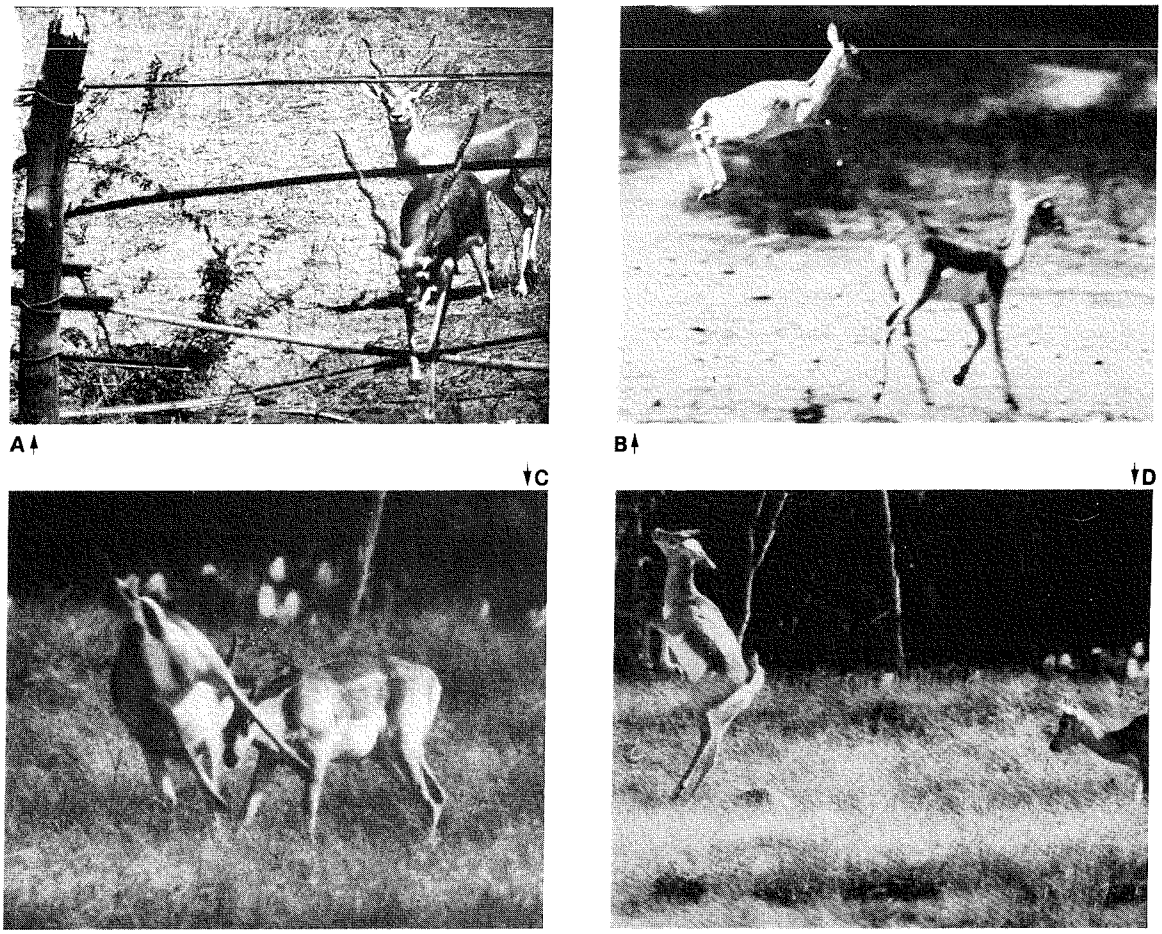


FIG. 4-1. Jumps used by blackbuck: (A) ordinary jump (photograph courtesy K. S. Dharmakumarsinhji), (B) "stotting," (C) "**Finten**," (D) "steep jump."

Frustration seems to play a part in the situations in which steep jumps are exhibited. Adolescent males occasionally perform such a jump during sparring (Fig. 4-1D), but more often they are given by subadult or adolescent females. For example, sometimes during play fawns repeatedly run past the females but never pass quite close enough to get butted. A young female may then throw her head into the air and shake it from side to side — "neck wringing" — once or twice at about the speed of a person shaking his head to indicate, "No." At the same time she rears up and pushes off with her hind legs. Her tail is often curled over her back. Other times, the head may only be inclined to one side, but the jump is just as steep. In any event, the animal looks in side view as if it has been twisted into a zigzag line. The head toss with neck wringing can also be given without quite leaving the ground.

Lying and standing

Lying and standing follow the pattern characteristic for the whole order Artiodactyla. The chest-side lying posture in which the legs are gathered close to the body and the upright head is turned over the side on which the upper-most hind leg lies is most common. Not even fawns lie flat on their sides.

During rest periods of an hour or so, each individual normally changes sides at least once. Although older antelope can change sides without standing up, only fawns do this regularly. This helps the fawns remain out of sight in their lying places.

Orientation toward the cause of a disturbance, the neck held vertically and the ears turned forward are key elements of the alert posture. Stamping and tail wagging sometimes occur, but not in ritualized form.

Vocalizations

Vocalizations sometimes associated with the alert posture are the "click call" and "sneeze call." Neither the click call nor the sneeze call — the "örr" call of Walther (1959-60) — is given in series. The click call is a low vocalization like the sound made by pulling one's moist tongue slowly down from the roof of the mouth without allowing it to touch the bottom. Walther (1959-60) describes it as sounding like "kn, kn," and Schmied (1973) characterizes it as a soft blow or snort. It is accompanied by a quick closing and dilation of the nostrils. Other animals were not observed to show any visible reaction to this call, but they were already on the alert themselves. After abandoning the alert posture, a few individuals of a group may continue calling intermittently for several minutes.

The sneeze call sounds like what appears to be a genuine sneeze as given by blackbuck in a dust laden wind. In both cases, it is usually given with a downward jerk of the nose. The noise carries well. Blackbuck often use this call when alerted but unable to locate the cause of the alarm. In such cases first one buck in a bachelor association and then another is particularly likely to utter the sneeze call at intervals as all the males start drifting away to another area. Sometimes a disturbed animal will stand and give the sneeze call in between bouts of stotting. When blackbuck discover an animal of an unfamiliar species (Schmied 1973) or a predator, such as a cheetah (Dharmakumarsinhji *in* Schaller 1967) or a raptor, in the vicinity, the sneeze call can also be given. This is particularly true for a doe who has a neonate fawn.

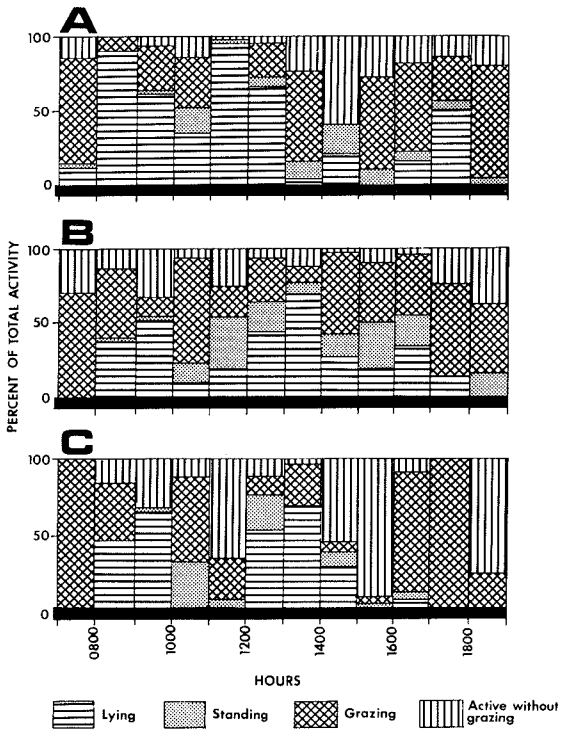


FIG. 4-2. Examples of day activity for blackbuck of three of the major social units: (A) bachelor association, (B) female group, (C) territorial male.

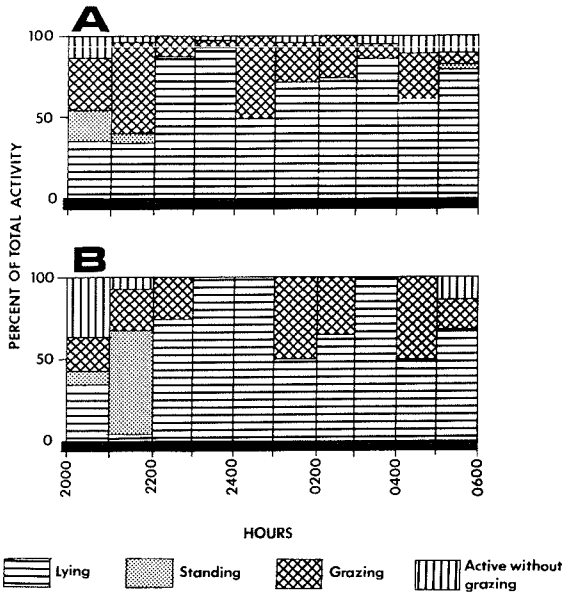


FIG. 4-3. Examples of night activity for blackbuck of two of the major social units: (A) female group, (B) territorial male.

The "rocho" call (sound characterization by Walther 1959-60) is a loud call which can resemble a series of sneeze calls. Typically it is heard as an advertising call from mature bucks in the nose-up display. Often the nose is bobbed down sharply as the puff of breath from each call is expelled, and the mouth is partially open.

Adults and immatures alike give a distress call when caught or roughly treated. Walther (1959-60) describes it as a long, loud "öööö" which brings the mother running if she hears it from her fawn; other herd members may also approach.

The low call with which the fawn answers its mother, a very soft, bleating "mä" (Walther 1959-60), sounds like the fawn's version of the mother's low contact call by which the young

blackbuck recognizes its mother. This ". . . nasal, very soft 'mm' . . . ." (Walther 1959-60, p. 68) is given at frequent intervals by first one animal and then another among members of grazing groups of females and young. A slight raising of the abdomen is often the only clue as to the caller's identity.

Diel Activity

The blackbuck's diel activity pattern — the 24-hour cycle of day and night activity — is polyphasic (Figs. 4-2 and 4-3). Its basic form is predictable, but variations in such environmental parameters as temperature, wind and moisture contribute to changes in its details.

Day

After rising at dawn blackbuck graze intensely (Fig. 4-2). The territorial male usually keeps apart. Fawns nurse just after their mothers rise. The bachelors may spar among each other. Then at about 0830 hours the blackbuck bed for the most pronounced rest period of the day. The dominant male with a group often forces animals who lie down before he does to rise. After he has settled, usually in one of the spots just vacated, they are free to bed in peace. When the rest period ends about an hour later, the dominant male moves through the group getting up animals who are not yet on their feet. This helps to coordinate activity.

Next, the animals graze and are active among each other for the remainder of the day except for lesser resting peaks in the middle of the day and in late afternoon (Fig. 4-2). Before the midday rest, almost all blackbuck retire to the shade if the temperature is getting hot (Fig. 4-4). After the midday rest, fawns nurse again and aggressive contacts between the males increase. By about 1700 hours, most of the animals are back in the open again and active (Fig. 4-4). Dusk brings the next nursing peak.

During daylight blackbuck spend about 40 percent of their time grazing. Activity levels in the other categories — lying, standing and active without grazing — tend to differ more depending on whether an animal is a female with a female group, a bachelor with a bachelor association or a territorial male with a female group (Fig. 4-2).

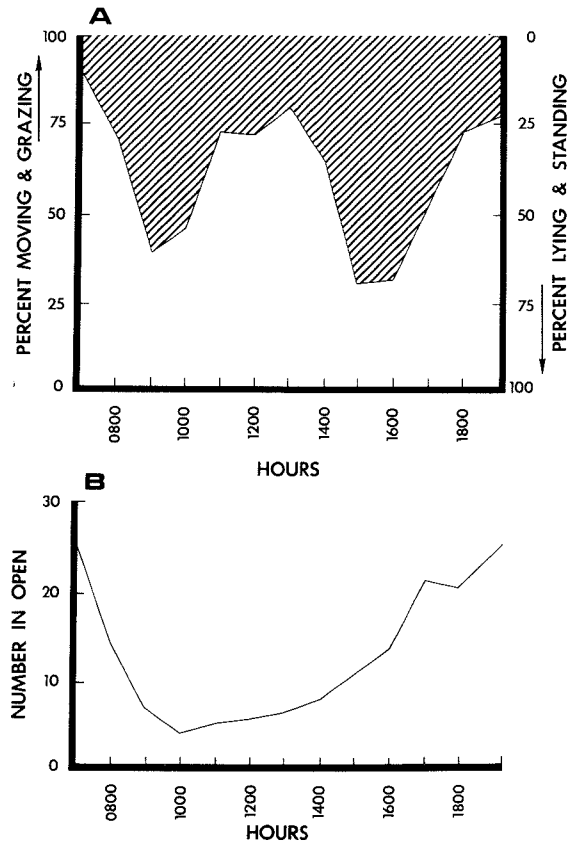


FIG. 4-4. Daylight use pattern in opening of large pasture as observed on a summer day from a fixed location: (A) comparison of activities and (B) number of blackbuck.

Night

At night (Fig. 4-3), the most constant category for animals of all social groupings is lying (65 percent on a moderately active night). Territorial bucks are active among the females on into the dark hours, but grazing finally predominates later in the evening and all the animals bed by about midnight. Young fawns rise and nurse briefly after this major resting peak. After midnight there are two possible intervals of renewed grazing activity, either or both of which may be surpressed by unfavorable weather conditions.

Weather effects

Use of open areas as compared with use of brush and shade illustrates the effect different environmental factors can have on activity patterns. Comparing time spent in the open in relation to time spent in sheltered areas demonstrates the effects of three parameters: heat, wind and wetness.

Under moderate conditions daylight brush use is random. On a hot day brush use increases significantly. Once the temperature, recorded in the shade, exceeds 32°C (90°F), blackbuck retire to the shade for their rest periods instead of lying in the open. In a strong wind, antelope in the open orient with their backs to the wind and flatten their ears to the side instead of holding them more upright in the normal, relaxed position. Nevertheles, they do not retreat to shelter unless the wind is in combination with another stress factor such as cold. Cold without wind showed the greatest change from random of any situation. The blackbuck compensated for low ambient temperatures by concentrating their activity in open places and sunning themselves. During brief cloudbursts, blackbuck assume the discomfort posture (Fig. 4-5; like *Unbehaglichkeitshaltung* which Walther [1964a] first described for the genus *Tragelaphus*) with their tails to any wind and stay where they are. If the rain is prolonged, they finally resume a more normal pattern of activity, including use of open areas as well as brush. All classes of blackbuck raise their hair in response to cold or wet conditions.

Play

Play often follows the end of rain or other improvement in conditions, such as morning warming after a cold night or sunset cooling after a hot day. The tendency of fawns to play after nursing reinforces the characteristic dawn and dusk peaks in play activity (Fig. 4-6). It does not create a sharp rise after the midday rest period, however, because the active displaying of bucks and other disturbances at this time of day often disrupt nursing and substitute flight for play.

Young blackbuck play much more frequently than adults. As the fawns associate more closely with each other, play changes from the solitary running games of neonates to contagious bouts of running games. These, in turn, change to play sessions which include not only galloping, stotting and trotting, which are executed by the animal as an individual, but also mounting, mount intentions, sparring, *Finten* and sometimes steep jumps, which all involve at least two animals. Adolescent bucks show increasingly greater continuity in their use of fighting techniques until they are much more likely to spar than to indulge in the other actions that have characterized their play up to this point.

Major Displays

The principal display used by blackbuck in social interactions is the nose-up display. Its counterpart is the submissive display. In its extreme form, submissive display is almost as infrequent as the nose-up display is common.

Nose-up display

The nose-up display has six main components. The first two, ears down and neck flexed with nose upward, seem approximately equivalent in the responses they elicit, and sometimes one is given without the other. The third, tail curled, is always combined with one and usually both of the first two. Thus, a curled tail indicates a higher display intensity. The fourth component may actually be an olfactory stimulus because the displaying buck opens his preorbital glands. Muscles circling the gland can express a paste-like secretion from a paired row of pores on the exposed surface. The fifth component is movement toward the recipient. Another sign that the display is becoming more intense is the sixth component, raising of the hair along the neck and body. This erector-pilli effect renders a dark buck suddenly darker because it masks the

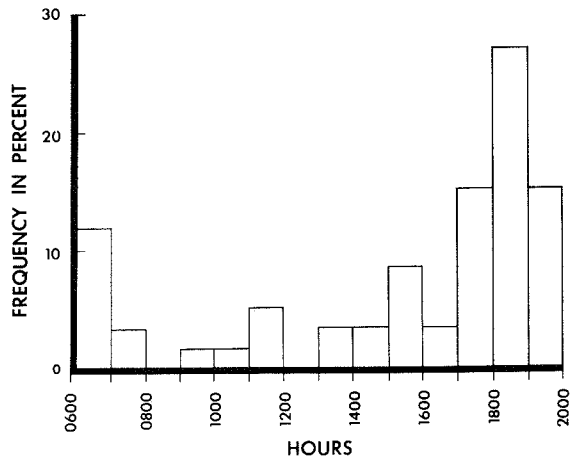


FIG. 4-6. Distribution of play sessions during two consecutive years. All sex and age classes are included.

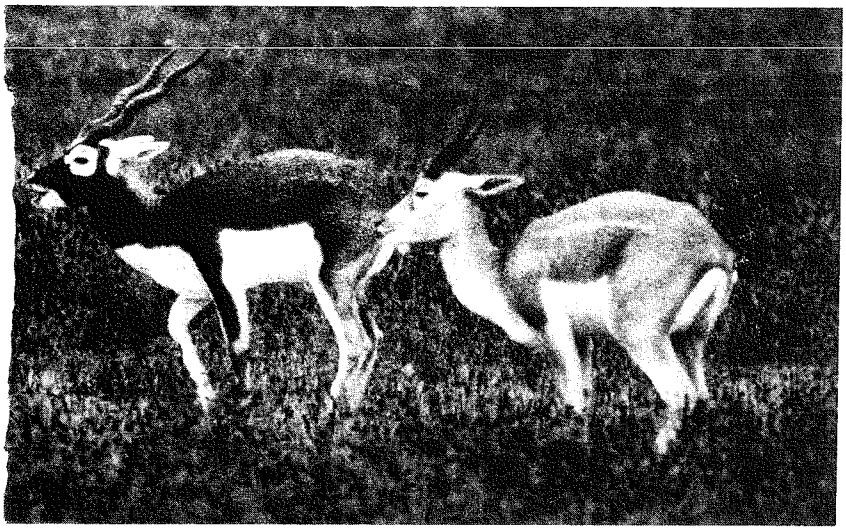


FIG. 4-5. Discomfort posture as exhibited during rain. Note the extremely short distance between adolescent and adult, the closed eye of the former, rumination in the adult and the way the adult is shifting in place to reorient after a change in wind direction.

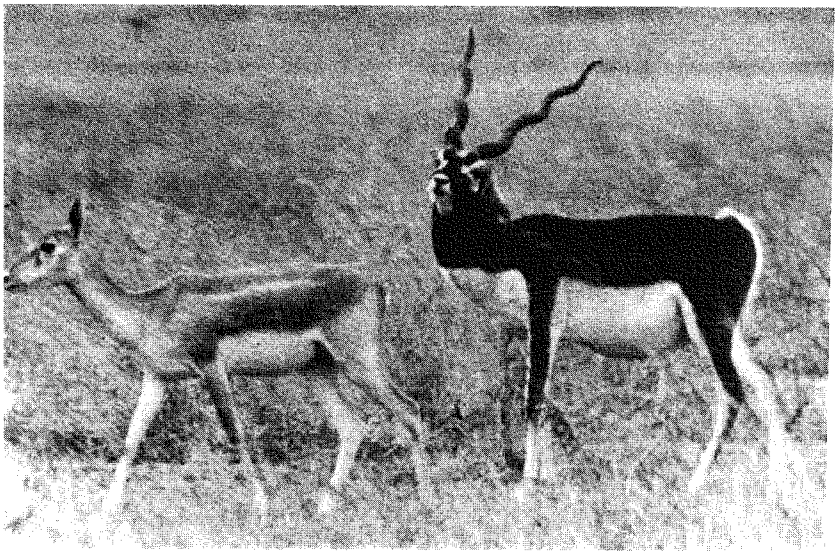


FIG. 4-7. A buck in full nose-lifted form of nose-up display to a doe. (Photograph courtesy of K. S. Dharmakumarsinhji.)

lower hair shafts which are generally tan. In addition, the buck may tilt his horns toward his object by inclining his head away, he may bob his head rhythmically while pacing, and he may utter a series of rocho calls. His white eye rings help make him conspicuous to the object of his display. Fig. 4-7 shows an Indian buck in full display to a doe.

The nose-up display may be divided into the nose-lifted form, in which the head is raised only approximately to the horizontal, and the extreme nose-up form, in which the head is raised considerably above the horizontal. In the nose-lifted form, which is characteristic of both herding and preliminary courtship, the other display elements tend to be exaggerated as the distance between two individuals decreases or as the pacing speed of the addressor increases. In the extreme nose-up form, which is used at very close quarters to make another animal move, forward progression may be lacking or, more commonly, may be represented by a rapid series of a few tripping steps folowed by a pause.

Both in sexual and nonsexual contexts, the correct response for the target of either form is to move. If a target does not move, then the addressor lunges at it and butts it or, in the case

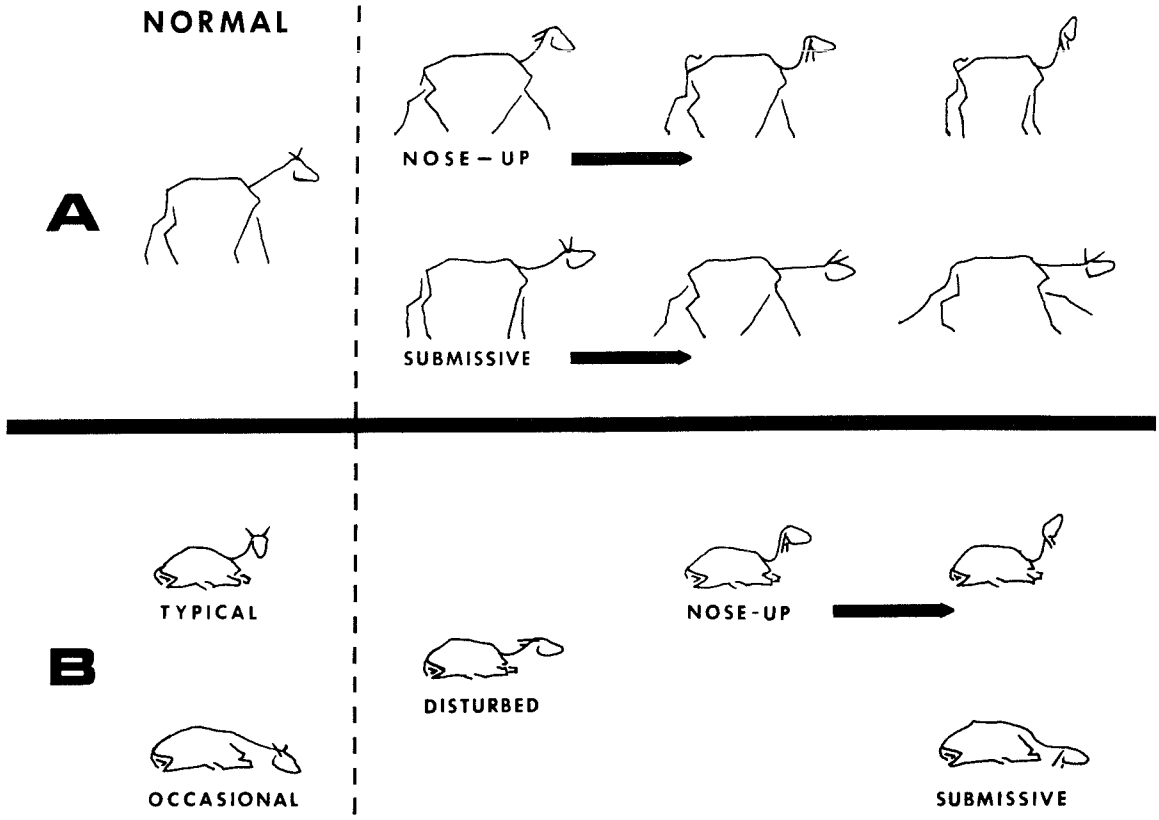


FIG. 4-8. Comparison of normal postures with both nose-up display and submissive display postures: (A) blackbuck on its feet and (B) blackbuck lying. Display intensity increases to right.

of males, thrashes the forward surface of the horns down over the target's haunches. As fawns discover at a young age, the nose-up display is no idle gesture.

Although so characteristic of the male, the nose-up display is by no means his sole prerogative; rather, it is used by any blackbuck taking a clearly dominant stance toward those (including individuals of other species) at whom the display is directed or by equals if sufficiently aroused. In this context, it becomes reasonable that the display is rarely given by females or by juvenile blackbuck.

Submissive display

Consistent with the principle of behavioral antithesis, the nose-up display and submissive display are distinctly different. The most striking contrast is that in the nose-up display the neck moves toward the vertical with the head held horizontally or higher, whereas in the submissive posture both head and neck are thrust forward horizontally. The frontal view presented by a blackbuck in nose-up display emphasizes any coat darkening, whereas the view of an escaping buck, once he can pass out of the broadside orientation into rear view, deemphasizes the darkening. A buck in nose-up display often advertises his presence with a series of rocho calls, whereas a buck in submissive posture remains silent. Although not as frequent, both of these displays can also be given from a lying position. Fig. 4-8, which compares the two displays, indicates why the mild form of the submissive posture often goes unnoticed, especially in females who often use it; the mild form is similar to the normal posture.

Animals often assume the submissive posture when running from a disturbance. The display only becomes conspicuous, however, when there is some hindrance to free flight, especially when the displaying antelope is in close proximity to whatever is eliciting the response. The uncommon extreme form is most often seen in

a spike buck who is trying to circle back into his female group while an adult buck in nose-up display is just as tenaciously trying to drive him away (Fig. 4-9).

General distribution of interactions

Table 4-1 gives the classes of addressors and addressees in 4,542 interactions observed for all classes of blackbuck over a 2-year period in a small Texas pasture. Most involved the nose-up display, but a few cases of mounting or butting with ears back did not. Although numbers of animals fluctuated during the observation period, the sex ratio stayed roughly equal. Only the block for territorial male versus territorial male is misleading. This value is abnormally low because for 14.5 months there was only one territorial male. Encounters involving nose-up display were observed for 1 year in a large Texas pasture with many territorial bucks. Of 1,844 such encounters for all classes of blackbuck, 18 percent of the 1,356 in which a territorial male was the addressor were between territorial males, while 23 percent of these 1,356 had a bachelor as addressee. Otherwise, there is good agreement.

Table 4-1 shows that territorial males initiate 60 percent of all interactions and that they together with all other adult and subadult males initiate 79 percent. Other than to bucks of like status, territorial males direct most of their displays toward adult and subadult bachelors (32 percent) Adolescent bucks receive the only other substantial proportion (22 percent). Bachelor adults and subadults show a similar pattern.

Adolescence brackets the period during which males make the transition from life in the female herds to life as bachelors. Consequently, animals in this category show a high proportion of interactions with females (52 percent). The adult and subadult females address most of their few butts and displays to other adult and subadult females (49 percent) or to fawns (40 percent). Adolescent females are quite inferior to the older blackbuck and are largely ignored. Fawns initiate more interactions (4 percent) than adolescent females (1 percent) mainly because the fawns are still nursing and because they are in close contact with each other for so much of the time.

Seasonal distribution of displaying and fighting

Comparing the distribution of displays for all adult and subadult bucks in the large Texas pasture throughout the year reveals that the territorial bucks show a high (43 percent) in the spring, whereas the bachelors show a similar high (42 percent) in the fall (Table 4-2). Spring

FIG. 4-9. Adolescent male in submissive display leaving female group with territorial buck following him in nose-lifted display.

TABLE 4-1. ALL INTERACTIONS INVOLVING NOSE-UP DISPLAY, MOUNTING AND BUTTING OBSERVED DURING 2 YEARS IN A SMALL PASTURE. NUMBERS ARE IN PERCENT EXCEPT FOR THE TOTAL NUMBERS OF CASES WHICH ARE IN PARENTHESES.

	ADDRESSEE							
ADDRESSOR	Territorial ♂	Adult & subadult bachelor ♂	Adolescent ♂	Adult & subadult ♀	Adolescent ♀	Fawn	Other species	TOTALS
Territorial ♂	6.2	32.0	21.8	37.8	1.2	1.0	0	100 (2,741)
Adult and subadult bachelor ♂	0.8	32.4	30.4	26.7	7.5	1.8	0.4	100 (851)
Adolescent ♂	0	17.1	16.9	51.7	2.6	11.2	0.5	100 (385)
Adult and subadult ♀	1.3	0	4.5	49.3	3.4	40.0	1.3	100* (377)
Adolescent ♀	0	0	8.0	52.0	12.0	28.0	0	100 (25)
Fawn	0	0	0	44.8	0	55.2	0	100 (163)
								(N = 4,542)

*99.8 with rounding error.

TABLE 4-2. SEASONAL DISTRIBUTION BY PERCENT OF INTERACTIONS INVOLVING NOSE-UP DISPLAY DURING ONE YEAR IN A LARGE PASTURE. NUMBER OF CASES OBSERVED IN PARENTHESES.

	SPRING*	SUMMER*	FALL*	WINTER*	TOTALS
Single territorial ♂ FX	39.5 (81)	13.2 (27)	28.8 (59)	18.5 (38)	100 (205)
All territorial ♂♂	42.6	15.8	24.3	17.3	100 (1,384)
All bachelor ♂♂ (adult and subadult)	20.6	21.8	42.3	15.2	100 (789)
					(N = 2,173)

*Spring = March through May; summer = June through August; fall = September through November; winter = December through February.

was taken as March through May, summer as June through August, fall as September through November and winter as December through February. Data for an individual territorial buck are presented to demonstrate the number of interactions a single animal may be observed in during a year. Among his Austrian blackbuck, Schmied (1973) noted that summer activity was particularly low and that there were highs in spring and fall.

The territorial bucks' spring high may reflect an increase in breeding activity or a peak associated with a return to more favorable environmental conditions. Since territorial bucks spend more of their time on a smaller area, they may be more affected by the spring improvement in range conditions than are other animals who are freer to concentrate their grazing wherever local conditions are best. The bachelors' fall high is related to a fall increase in the initiation of territorial activity. In one of the Texas pastures all but one of the changes in territorial status or location of territory observed came during this period plus the last week of summer.

Although much less frequent than nose-up display, actual fights show a similar distribution. In the same large pasture most fights were

TABLE 4-3. SEASONAL DISTRIBUTION BY PERCENT OF HIGH INTENSITY FIGHTS OBSERVED DURING ONE YEAR IN A LARGE PASTURE (SAME PASTURE AND PERIOD AS FOR TABLE 4-2). NUMBER OF CASES OBSERVED IN PARENTHESES.

	Spring	Summer	Fall	Winter	Totals
Single territorial ♂ FX	30.8 (4)	0 (0)	61.5 (8)	7.7 (1)	100 (13)
All adult and sub-adult ♂♂	32.1	9.4	49.0	9.4	100* (53)

*99.9 with rounding error.

observed in spring and fall with the fall total decidedly greater (Table 4-3). Again, the totals for one territorial buck, the same one, are given separately to illustrate the involvement of an individual. Schmied's (1973) Austrian blackbuck exhibited a similar pattern.

Fights

Although all intermediate types are possible, fights in blackbuck may be divided for convenience of discussion into low intensity and high

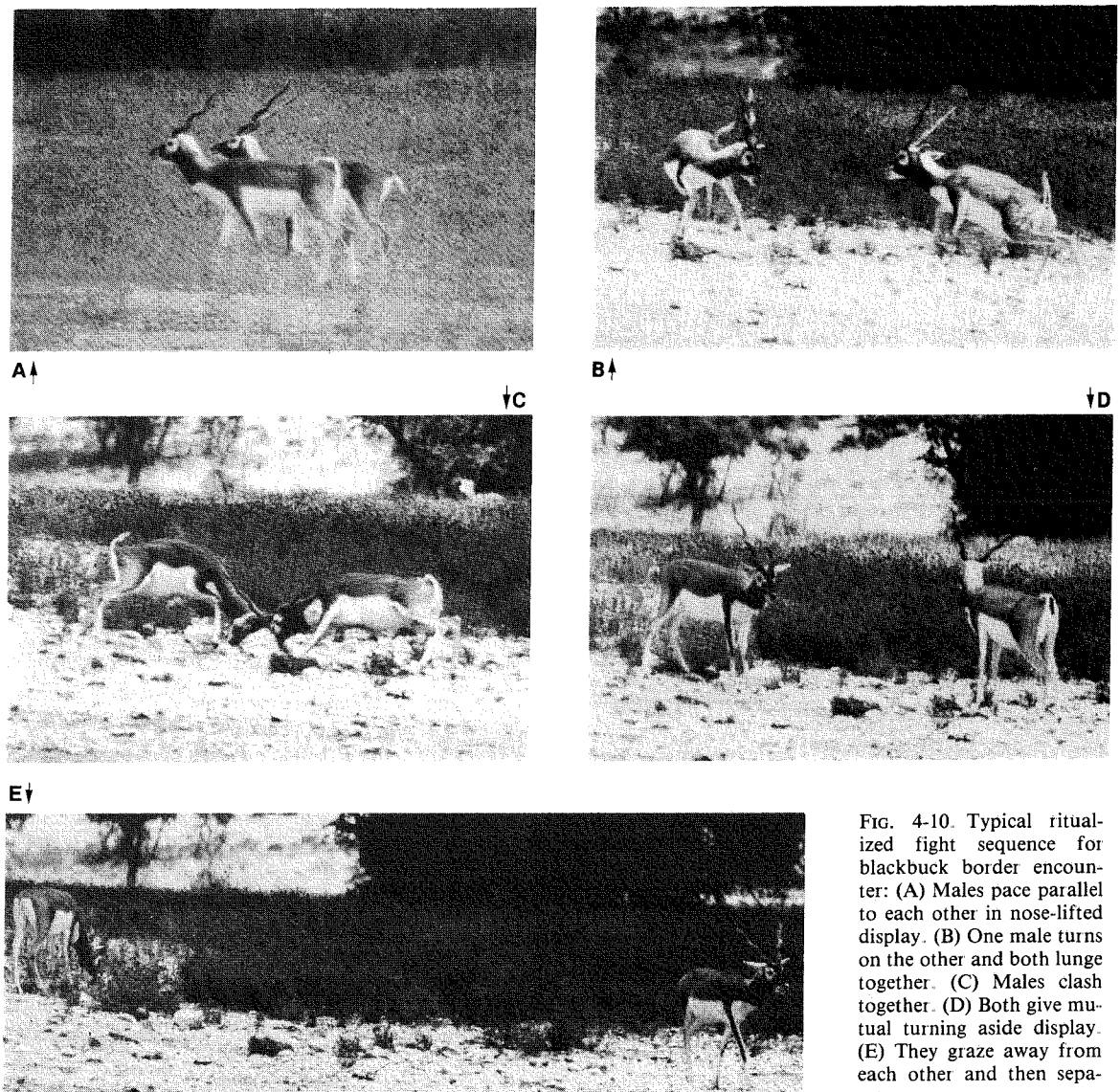


FIG. 4-10. Typical ritualized fight sequence for blackbuck border encounter: (A) Males pace parallel to each other in nose-lifted display. (B) One male turns on the other and both lunge together. (C) Males clash together. (D) Both give mutual turning aside display. (E) They graze away from each other and then separate.

intensity. When a fight varies in intensity, it usually grows more intense.

Low intensity

During low-intensity fights body involvement is minimal. The head and the neck move, but little force is transmitted to the opponent. Examples are the frequent sparring matches among bachelors and the playful fights of fawns and other juveniles. Juveniles are particularly likely to jump during fights. Territorial males were never observed in low intensity fights.

High intensity

High intensity fights are those in which the whole body of each animal is involved in the actions. All serious fights in which the combatants struggle against each other are of this kind. The two main types are the "ritualized fight" between two territorial bucks and the "long fight" between a territorial buck and a bachelor. Fights of these two types begin with the two bucks pacing parallel to each other in the nose-up display (Fig. 4-10A). Finally one turns on the other (Fig. 4-10B), and they clash (Fig. 4-10C).

In a ritualized fight, the bucks separate immediately and then either clash again or go into a "mutual turning aside" display (Fig. 4-10D). These two elements are repeated until both bucks are ready to separate by grazing away from each other. When a safe distance apart, either, or both, can raise his head and leave (Fig. 4-10E). Lower intensity border encounters have the same beginning and ending but no clashes.

While ritualized fights may last 2 minutes, determined challenges may last 2 hours, but they develop much less often. One buck may be observed in three long fights during a year, whereas one buck may be involved in three border encounters during one day. In these long fights extended sessions with head against head follow the clashes (Fig. 4-11). The combatants keep their heads low during the pauses between clashes (Fig. 4-11) instead of going into mutual turning aside, and the session ends with a definite winner who chases the loser.

Techniques used by blackbuck minimize the risk of injury by turning fights into contests of strength and endurance. Injuries are rare unless defeated bucks do not have sufficient room and cover to stay away from an aggressive opponent.

Courtship

The nose-up display is also the blackbuck's courtship display. During the preliminary phases, the buck paces behind the doe in the nose-lifted form. This constitutes the "mating march" (Fig. 4-12A). The female moves ahead in normal posture. As the female becomes receptive, she begins moving in circles which become tighter and tigher. Backhaus (1958) rela-

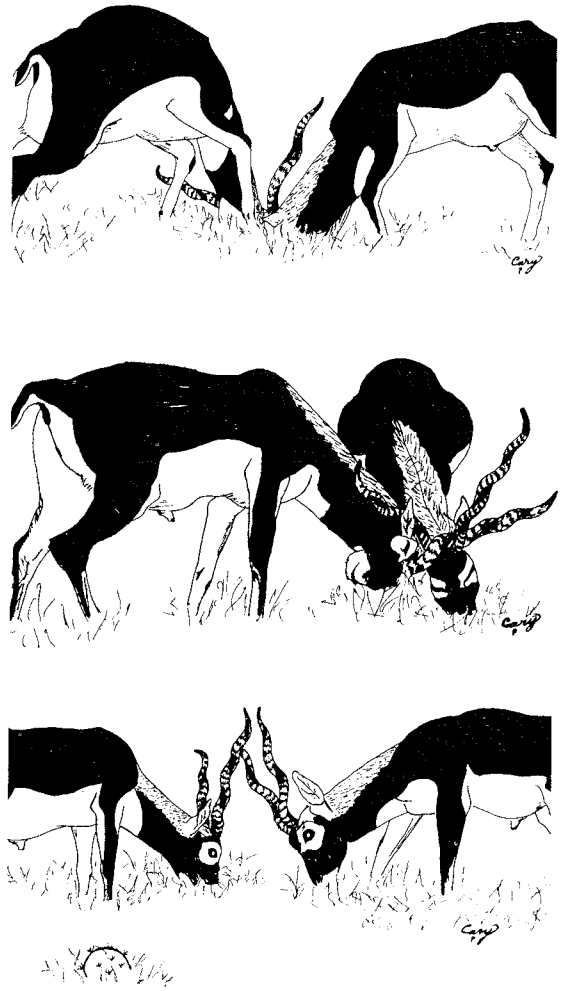


FIG. 4-11. Extended bouts of pushing with head against head following clashes in a long fight. A clash initiates the pushing (top). Necks and heads turn as horns remain locked at bases (middle). Combatants face each other with heads low during a pause.

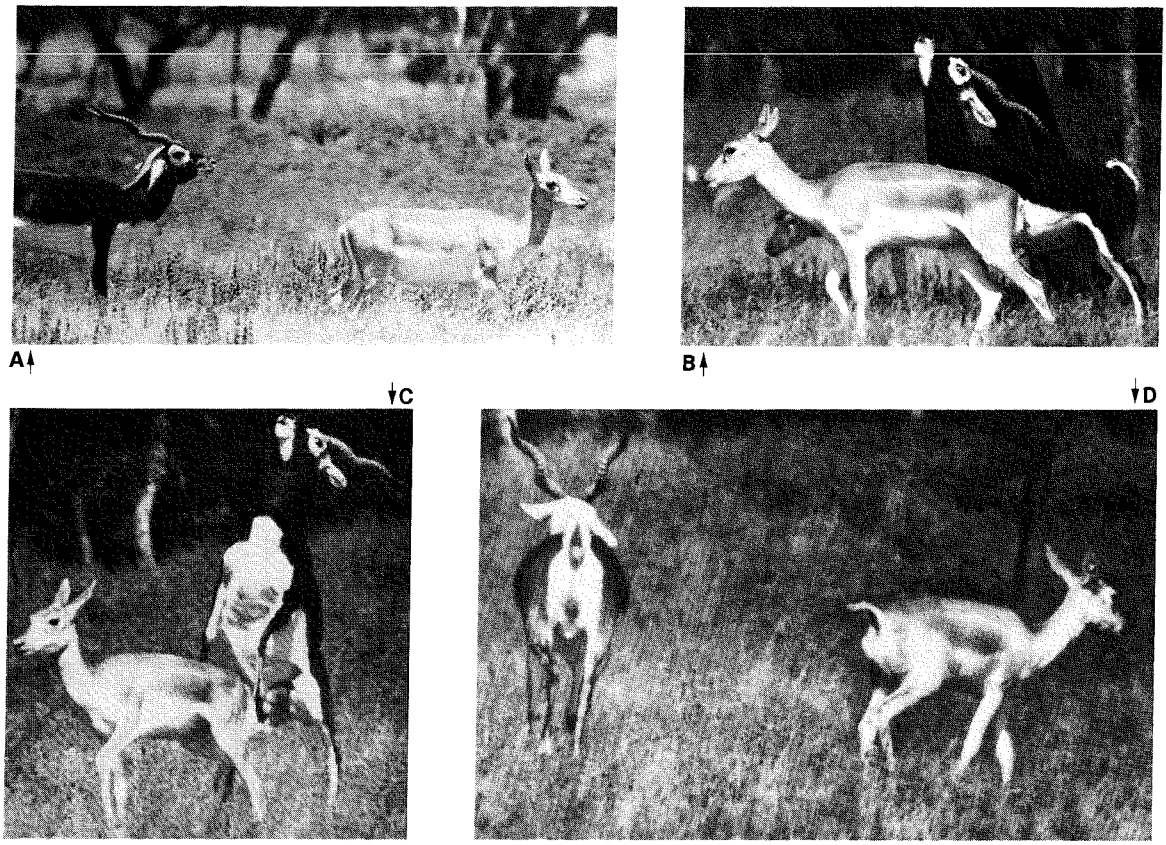


FIG. 4-12. Courtship and mating sequence: (A) Buck in nose-lifted form of nose-up display paces behind female moving away in normal posture ("mating march"). (B) Buck in extreme form of nose-up display during close courtship advances toward female who then moves away at a slow pace. Note that female's head is turned slightly toward buck and that buck's chin patch is exposed. (C) Buck gives high, steep mount used for copulation. (D) Buck leaves female after successful courtship. Note female's raised tail and slightly arched back.

tes this circling to attempts by the female to keep the buck in view. First, she circles to one side and then to the other. Now the buck starts repeated use of the extreme nose-up display which prominently exposes his chin patch at the same time that it moves his horns away into a less conspicuous position (Fig. 4-12B).

In close courtship the buck is continually trying to realign himself direclty behind his doe. The female's circling movements are sporadic, coming in response to the buck's quick advances in the extreme nose-up display combined with a series of tripping steps. If a doe fails to move in response to his quick approach, the buck comes closer next time. In doing so he sometimes even pushes her lightly with his chest or lower neck. If she still remains he thrashes his horns down over her haunches. Toward the end of those close courtship sessions that include it, thrashing may occur as often as twice a minute. As close courtship continues the female may wag her tail in brief bursts. Later the buck may start nosing the vulva, stretching his head and neck toward it and seeming to lick the surface.

If another doe is standing near the pair, she may butt the female or even the buck, but he takes no notice (Cary 1976b). When nearby males interrupt close courtship with their own advances to the doe, the courting buck chases them off. Adolescent males with a female group are the worst offenders. These interruptions can be as frequent as once a minute. The courted doe grazes or stands where she is until her buck returns.

For successful mounting, it seems the doe must move forward but not too fast. After each unsuccessful mount the buck goes back to standing behind the female in the nose-lifted display and resumes intermittent approaches in

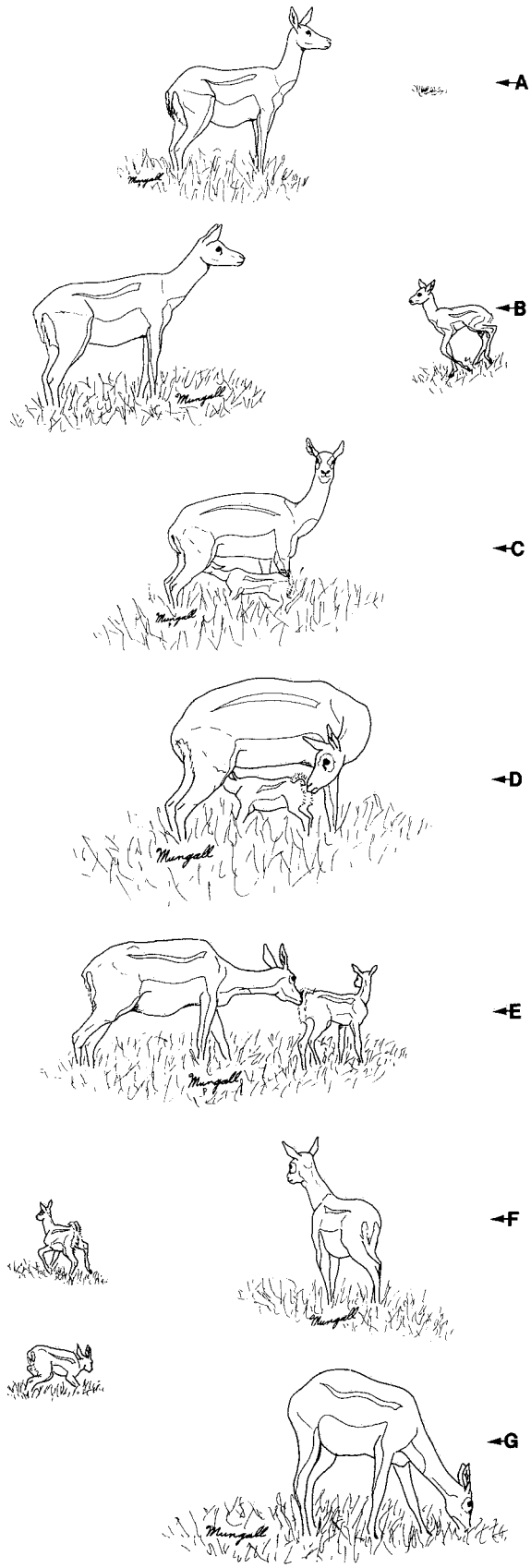


FIG. 4-13. Major components of the contact session of mother with her young fawn: (A) Mother returns to area where fawn is bedded and calls it. (B) Fawn rushes to mother. (C) Fawn assumes reverse parallel position for nursing. (D) Mother sniffs fawn to check its identity as nursing begins. (E) Mother finishes cleaning urogenital area as fawn starts to wander. (F) Fawn plays briefly near mother. (G) Fawn leaves mother and chooses a bedding site as mother grazes.

the extreme nose-up form. The latter are intention movements for mounting. Barring outside interference, this constant circling and repetition keeps the two animals together long enough for their state of readiness to become synchronized. In six observations, courtship varied from 3 to more than 40 minutes.

Copulation terminates courtship. Unlike noncopulatory mounts, copulatory mounts are very steep (Fig. 4-12C). The buck rears up with his neck at or near the vertical and with his nose raised. He neither rests on the doe nor clasps her with his forelegs. Successful or not, this steep mount is held only for an instant.

When intromission is achieved the buck leaves the doe. She may stand where she is for a few minutes or she may move slowly away and then commence grazing. Her back is slightly arched, and her tail is raised (Fig. 4-12D). Soon she rejoins the other females.

As soon as copulation is successful, the buck switches his attention to another buck. If no bucks are close by, he seeks one out. The successful suitor follows the other in the nose-lifted display and may chase him. This final show of force may serve to discharge the remaining aggressive component of the courtship ceremony after the sexual drive has been consumed. Thus the aggression in its pure form is directed toward a target other than the doe.

Fawns and fawning

Not all females separate from the herd before parturition, but all keep other blackbuck at least 10 m (11 yd) away from the birth site. If necessary an expectant mother will assume the full form of the nose-up display and run off any who refuse to leave. As in the births observed in the Zurich Zoo (Benz 1973) and at the Austrian experiment station (Schmied 1973), the Texas doe observed in a large pasture alternately lay and stood during the first phases of labor and

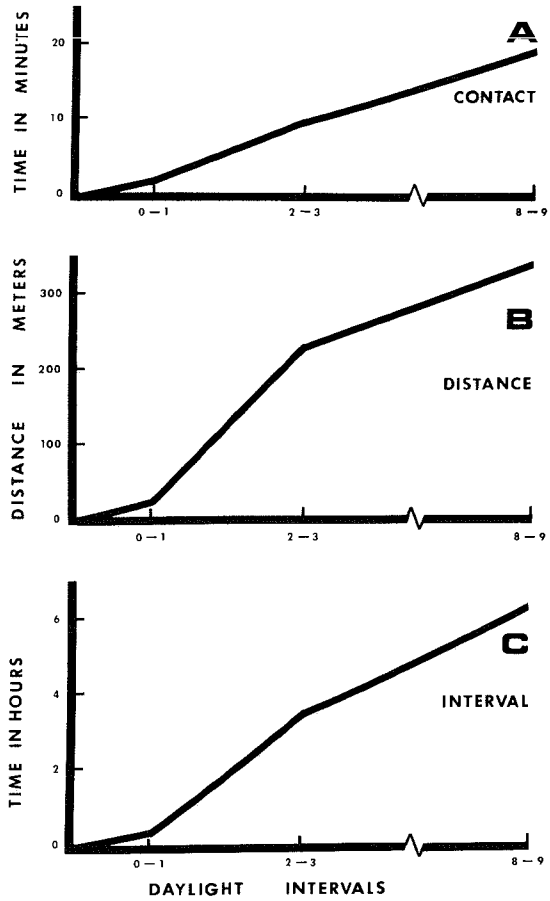


FIG. 4-14. Trends noted during daylight observation of a fawn's first week: (A) average duration of contact sessions (from the time the fawn first rose from its bedding site to the time it bedded down again), (B) average distance between bedding sites, (C) average interval between contact sessions. Given for comparison are the calendar day of birth (0-1), the second calendar day (2-3) and the day after the fawn turned a week old (8-9). Birth starts the fawn's day 1.

was lying during the final expulsion of the fetus. The new mother then localizes her activity in the neonate's vicinity for the next 2 to 3 days, often maintaining an increased distance from other group members even if with the herd.

The blackbuck fawn is of the lying-out type. Instead of staying with the mother as the young of follower species do, it leaves the dam and beds soon after it has nursed, urinated and defecated. The mother then withdraws, and the fawn remains lying until she returns and calls. Except indirectly, the doe has no influence over her fawn's choice of bedding site. Fig. 4-13 illustrates the main components of a contact session between the mother and her fawn.

For its first week, the Texas fawn remained in the open using an area of about 9 ha (22 ac) surrounding the birth site. From the fawn's 3rd day, the Texas mother was out of sight of her fawn's bedding place for increasing periods. By the fawn's 7th day, the dam was spending more and more time with the other females, and her behavior toward the other group members had returned to normal.

Before 1 week of age, the fawn may succeed in nursing more than once during a contact session. Average times for undisturbed nursing decrease as the fawn grows older. During its first days, 1 to 3 minutes or even close to 5 minutes is not exceptional. At nearly 2 weeks, 15 to 30 seconds becomes standard. Thereafter, times as long as 30 seconds are still observed, but many sessions are less than 5 seconds.

Other changes are also rapid. The fawn remains active for longer periods after bedding, so the contact sessions lengthen (Fig. 4-14A). The distances covered during play or travel with the mother increase, so consecutive bedding sites tend to be farther apart (Fig. 4-14B). Concurrently, the interval between contact sessions is extended until by about 1 week of age they become roughly stabilized at dawn, midday and dusk (Fig. 4-14C). There is also a late night contact session.

Summary

To appreciate complex behavior sequences, one must first understand the simple behavior patterns the blackbuck uses. Locomotor patterns, lying postures and vocalizations are prominent among the simple behavior forms.

The diel activity pattern is polyphasic. Changes in environmental parameters such as temperature, wind and moisture produce variations in details of the activity pattern. Play frequency shows peaks related to environmental conditions. Young blackbuck play much more than adults.

The principal display used by blackbuck in social interactions is the nose-up display. It has two forms: the nose-lifted form which is quite common and the extreme nose-up form which adult bucks use most strikingly in the final phases of courtship. The submissive display, which is the counterpart of the nose-up display, is usually seen only in its milder forms.

Adult and subadult males, particularly territorial males, initiate most aggressive and sexual interactions. The territorial males show a spring peak in display activity. Bachelors show a fall peak of similar magnitude. Although the number of fights also exhibits a spring high, the fall level is greater.

Fights are characterized as those of low intensity, in which body involvement is minimal, and those of high intensity, in which the whole body of each combatant is used in the struggle. Territorial males were never observed in low intensity fights like the sparring matches among bachelors. The two main types of high intensity fights are the ritualized fights in border encounters between territorial males and the "long fights" between territorial male and bachelor. Only the latter type produces a definite winner, and a territory can change owners as a result. Long fights are uncommon, however.

Courtship has two stages. The "mating march," in which the buck in nose-up display follows the doe, constitutes the preliminary phase. The final phase, "close courtship," begins when the doe starts moving in tight circles and the buck makes intermittent approaches in extreme nose-up display. Copulation terminates courtship. Immediately afterwards the buck leaves the doe to wander back among the other females while he finds another male and displays to him. This discharges the remaining agressive component of the mating ceremony toward an appropriate object.

Not all females separate from the herd before parturition, but all keep other animals away from the birth site. For at least 2 to 3 days after fawning, the mother remains in the vicinity of her fawn. After a week, she spends increasing time traveling with the other females again.

The blackbuck fawn is of the lying-out type. After nursing, urination and defecation, the fawn remains with its mother only a short time before wandering off and choosing a bedding site for itself. Then the mother leaves. This basic routine remains the same, but there are rapid changes in time spent nursing, time active after nursing and distances traveled. The mother's contact sessions with her fawn soon tend to stabilize at 6-hour intervals starting at dawn when the mother rises and goes looking for her bedded fawn.

(Fritz R. Walther contributed to Chapter 4.)

5

AGE DETERMINATION

☐ A reliable method for assigning ages to animals has many benefits. The manager can then work out the age composition of herds or populations, the life expectancy of these animals and the classes most vulnerable to various sorts of mortality. As well as defining the stability and potential of populations, he can monitor management schemes such as hunting programs. What ages are being withdrawn? Which are satisfactory trophies? Above a certain age, have bucks usually split or worn the tips of their horns and consequently lowered their trophy value? If there is a natural disaster, such as the winterkills that periodically affect populations on the Edwards Plateau, a manager can discover whether the adults that have died are mainly very old animals or a mixture which includes prime breeding stock as well. How old are the animals being offered for sale? Is a given animal capable of reproduction? Is an orphaned fawn old enough to survive without its mother? How much longer will it be before a particular juvenile male separates from the females? Questions of age are involved in all aspects of management.

Answering these questions requires two different schemes correlated with each other: one for live animals which does not require physical contact and one for skull material which does not require the rest of the carcass. During field observations from 1971 to 1975, emphasis was placed on gathering descriptions and photographs of many individually known animals and a few animals of known ages. The results were correlated with data from skeletal material collected between August 1970 and January 1977. Nine Texas ranches donated material directly, and area taxidermists contributed jaws. Almost all of the more than 500 samples came from the Edwards Plateau; the majority came from two particular ranches on which large populations had experienced die-offs. Zoo measurements from four fawns, and

notes on a known-age Hill Country doe helped establish ages. Three known-age skulls also supplement these data: one from a grown pasture buck observed in the Hill Country during this study, one from a buck in a Texas zoo and one from a young female raised in the London Zoo. Information for the female (skull no. 74.463) was in the form of photographs from the British Museum (Natural History).

Skull material

Most of the skull collecting was done by searching on foot through pastures and examining all bones found. The first problem was to distinguish blackbuck skulls from the others. The blackbuck's prominent orbits and square lower jaw were the most helpful field characteristics. The most common of the other species in the blackbuck's size range was the white-tailed deer. Differences in lacrymal pit structure, jaw shape, tooth structure and horn-core or antler-base formation precluded mistakes. Sheep skulls are most similar, but, fortunately, sheep were rare or absent in the blackbuck pastures were effort was concentrated. Appendix C summarizes the chief characteristics used to differentiate blackbuck skull material from that of the other ungulates likely to be present.

General skull characteristics

Blackbuck have front teeth only in the lower jaws (the mandibles). In adults the shovel-shaped center teeth are the right and left first incisors (right and left I1). Flanking these is a pair of teeth only slightly flared above the socket level, the right and left second incisor (right and left I2). Next comes a peg-like third incisor (right and left I3) and an incisiform canine (right and left C). These teeth work against a hard pad in the upper jaw which has no front teeth. The front milk (deciduous) teeth are the same but smaller. Listed for one side only, they are i1, i2, i3, c. Fawns also have a right and a left upper canine but they are set farther back and do not occlude with the other teeth. The permanent cheek teeth are two premolars (Pm3, Pm4) and three molars (M1, M2, M3) below and three premolars (Pm2, Pm3, Pm4) and three molars (M1, M2, M3) above on each side. The deciduous dentition is equivalent except for the addition of a lower second premolar (pm2) and the absence of molars (pm2, pm3, pm4, both below and above). To keep the numbering system consistent with that used for other mammals, the premolars are designated pm2, pm3, pm4 instead of pm1, pm2, pm3 because species in other gorups with four premolars have been described. For one side only, the blackbuck's tooth formulae are $I\frac{0}{3}$ $C\frac{0}{1}$ $Pm\frac{3}{2}$ $M\frac{3}{3}$ for the permanent dentition and $Di\frac{0}{3}$ $Dc\frac{1}{1}$ $Dpm\frac{3}{3}$ for the deciduous (D) dentition.

The adult dentition differs slightly from the typical bovid complement by not replacing deciduous pm2 in the mandible. Some adults do have a second premolar in one or both mandibles, but these teeth appear to represent cases in which Pm3 during its eruption failed to contact and force out deciduous pm2 as normally happens. No indications of replacement of pm2 by a permanent counterpart Pm2 have been found. The mandibular pm2 does not necessarily even start to form until a day or two after birth. Rarely, none ever develops. With its short, broad nose, blackbuck may be slowly evolving toward the time when the species will have no mandibular second premolar at all.

The upper canine is the other deciduous tooth which is never replaced. It projects forward inside the mouth like a little tusk. Its tubular socket is just behind the juncture of the premaxillary and the maxillary bones. The convolutions the maxillary sometimes takes at the juncture itself must not be mistaken for traces of this socket. The upper canine is already fully formed at birth. At about 6 months, decay seems to set in at the neck. The tooth soon snaps off and is lost. The socket fills rapidly, although its last signs may linger on for another 3 years. Since after death the upper canines fall away even more readily than incisiforms do, and since the premaxillaries and often the tips of the maxillaries have frequently been chewed before skulls of natural deaths are recovered, the upper canine's value as an indicator tooth is limited. However, all sufficiently complete skulls of young fawns collected in this study had these teeth or had well defined sockets for them. Ritchie (1940) found rudimentary upper canines in a 1-day-old fawn but found well-formed evidence in both a 3-day-old fawn and a fawn that died at or within a few days of birth. Upper canines in blackbuck have never been observed to be either retained into adult life or replaced.

TABLE 5-1. TOOTH ERUPTION SEQUENCE IN BLACKBUCK ANTELOPE. LETTERS IN PARENTHESES INDICATE DECIDUOUS (D) OR PERMANENT (P) TEETH ABOVE GUM BUT NOT YET FULLY ERUPTED.

	UPPER JAW							LOWER JAW								
	Canine	Premolars			Molars			Incisors			Canine	Premolars			Molars		
	1	2	3	4	1	2	3	1	2	3	1	2	3	4	1	2	3
Birth	(D)	(D)	(D)	(D)				(D)	(D)	(D)	(D)		(D)	(D)			
	D	D	D	D				D	D	D	D	D	D	D	(P)		
	D	D	D	D	(P)			D	D	D	D	D	D	D	P		
	D	D	D	D	P			D	D	D	D	D	D	D	P	(P)	
	*	D	D	D	P	(P)		D	D	D	D	D	D	D	P	P	
	*	D	D	D	P	P		D	D	D	D	D	D	D	P	P	
	*	D	D	D	P	P		P	D	D	D	D	D	D	P	P	(P)
	*	D	D	D	P	P		P	P	(P)	(P)	D	D	D	P	P	(P)
	*	D	D	D	P	P	(P)	P	P	P	P	*	(P)	(P)	P	P	(P)
	*	P	P	P	P	P	(P)	P	P	P	P	*	P	P	P	P	(P)
	*	P	P	P	P	P	P	P	P	P	P	*	P	P	P	P	P

*Tooth is lost and not replaced.

Tooth eruption

The sequence of tooth eruption gives one indication of relative age. In this study, the eruption sequence was first based on comparison of 320 jawbones. Later the sequence in both upper and lower jaws was checked against the rest of the material collected. Table 5-1 shows the typical pattern. Occasionally eruption of a tooth on one side is retarded compared to that of its counterpart on the other side. Sometimes upper as well as lower jaws on the same side have been slower to develop. Nevertheless, these differences were small. The most obvious cases involved I2, I3 and C (mandibular).

Because of the variability of the developmental state of the incisiform teeth when compared with that of the molariform teeth, one or the other must serve as the reference point for defining the immature tooth classes. The molariforms were chosen in this study both because of the longer period of time over which these teeth erupt and because the incisiforms are frequently unavailable. After death they are quick to loosen in their sockets and fall away. In addition, this part of the jaw is often chewed before the skulls are found.

Cementum line counts

The numbers of annuli in the cementum of I1 and Pm3 were used to define age classes for animals in which all permanent teeth were already in place. Since early work in 1932 (Eidmann in Spinage 1973) this technique has been applied to a variety of terrestrial and marine mammals (Spinage 1973). Many of the applications have been to cervids and to bovids. Basically rings in the cementum of the teeth, like tree rings, are the result of differences in growth rates between seasons when survival is easier or more difficult. Specifically, it is presently thought to be the growth rate of the ostein matrix that varies (Spinage 1973). Wide, light bands alternate with darker staining, narrow bands. Blackbuck were postulated to form one light band and one dark band each year (Fig. 5-1). This hypothesis subsequently proved to fit the data well.

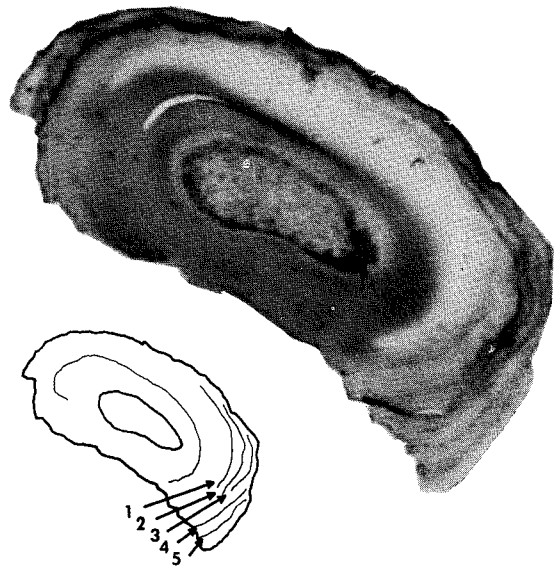


FIG. 5-1. Cross section of a blackbuck premolar stained to show cementum annuli. Sketch indicates position of the five pairs of light and dark rings revealed in this section. (Photograph by Robert W. Spain.)

Initially, the project had no known-age skulls. Samples were prepared for cementum ring counts by cutting the crown from the root of the extracted tooth at the cemento-enamel interface. Sections were then sliced from the cementum pad and "boss" with a Dremel Moto-tool and ground down with a grinding head attached to the same tool. The sections were then treated according to the method described in Erickson and Seliger (1969) except that 10 percent strength formic acid was used for 35 to 45 minutes for demineralization, sections remained in the stain 10 to 15 minutes followed by a 2-minute rinse instead of a 1-minute soak and egg albumen was the mounting medium employed after the dehydration procedures.

I1 and I2 were chosen for sectioning because two observations on age at eruption were available. In a Hill Country blackbuck doe on the Kerr Wildlife Management Area, the I1's were observed erupting at 14 to 15 months and the 12's at 17 months (Harmel pers. comm.). Annuli proved discernible in I1 but not in I2. Therefore, the estimated age was the age at I1 eruption plus one year for each dark cementum ring counted.

The small number of skulls for which incisors were found forced a further step. A consistent relationship was sought between the eruption of I1 and I2 and the eruption of a molariform tooth. In a series of 200 mandibles, it appeared that Pm3 had erupted shortly after I2. In two specimens, I2 and Pm3 had erupted at approximately the same time. Consequently, it was hypothesized that Pm3 erupts at about 18-20 months. For verification, cementum counts in I1 and Pm3 were compared, a correction factor for the difference in eruption time between I1 and I2 and between I2 and Pm3 being used. In most cases, the annulus counts in the cementum of I1 and Pm3 were identical, but in some teeth there was one more ring on I1. This is understandable since I1 erupts first and can, thus, form a ring before Pm3 erupts. Pm3's from specimens represented by a complete skull collected before the summer of 1972 were sectioned. Once age had been estimated, all the mandibles from all the complete specimens were grouped into age classes.

All skulls with Pm3 not yet erupted were considered to be from animals under 18-20 months. All those with Pm3 in place were put into age classes based on the number of dark cemetum rings in Pm3. The distinguishing characterists shared by each class were then recorded.

Tooth eruption-and-wear classes

At the close of the cementum count project, all skull material with enough teeth present was divided into classes on the basis of tooth eruption and wear. Qualitative characteristics stressed were relative amount of dentine visible on the tooth crown, presence and appearance of infundibula and degree of attrition of crests. Tooth height — which has been used to advantage in such species as white-tailed deer (Severinghaus 1949), black rhinoceros (Goddard 1970), impala (Spinage 1971), African buffalo (Grimsdell 1973) and Grant's gazelle (Spinage 1976) — could not be used for blackbuck because, as Dow and Wright (1962) found in pronghorn antelope, the teeth continue to push upward throughout life so that in all but the oldest animals a relatively constant height is maintained above the gum. This was corroborated for blackbuck by measurements of I1 height from neck upward and M1 height from gum upward (measured for 72 skulls) with animals of all but the oldest age class represented.

After the classes were defined the three known-age skulls were compared (the London skull by means of photographs) with the series. On this basis the provisional ages assigned with references to I1 and I2 eruption in the one Hill Country doe previously mentioned were increased 4 to 6 months. Considering the inherent variability already established for incisor development, the shifts seem within reasonable limits.

Next, the skulls in the highest cementum-count range were divided according to progressive loss of infundibula and the stage of tooth attrition. Due to resorption, cementum counts are inaccurate for old animals, giving only an index of minimum age attained (Spinage 1973). Tooth wear characteristics as age indicators also become more approximate as increasing age magnifies variations due to differences in diet and in the amount of abrasive inorganics ingested with feed. In jaws of 1- to 1.5-year-old white-tailed deer from a sandblown area and a dry, dusty area, molar wear already approxima-

ted that of 2- to 2.5-year-old deer elsewhere (Seveninghaus and Cheatum 1969). Even when comparable amounts of plants are eaten, teeth wear faster when animals take in more sand and dust because overgrazed range has forced cropping closer to the ground. Healy and Ludwig (1965) demonstrate this for sheep in New Zealand where animals on heavily used pasture have to be culled at younger ages because they can no longer graze efficiently. Because of this faster wear, the three oldest classes were assigned spans of 2 years each rather than being assigned differences of 1 year as for the preceding classes established on the basis of cementum counts. Assuming that among the 501 animals represented in the final sample a few had approached the maximum longevity recorded for the species, the old age classes were apportioned so that the whole range would be covered. Aside from parasitism and periodic winterkills, the populations represented by these skulls probably lose most adults to causes associated with old age.

Longevity would seem to approach 16 years as its biological limit. A female in the New York Zoological Park died at the age of 15 years 7 months 7 days (Crandall 1964). Life spans slightly longer were suspected for a few of their animals, but precise birth dates could not be established (Crandall 1964). An individual lived in Antwerp Zoological Gardens for more than 15 years 1 month 25 days (Flower 1931). Deaths in the 12- to 13-year range seem more common. A pair of Austrian blackbuck lived longer than 12 years — the male 12 years 8 months and the female 12 years 4 months (Schmied 1973). In his captive food study, Dharmakumarsinhji (1967) had live blackbuck of 12 (male), 10 (female) and 9 (female) years. Thus, 12 years seems a logical dividing point between two of the classes, each spanning 2 years, and 16 years is the indicated upper limit for the oldest class.

Appendix D gives detailed descriptions of the 25 tooth eruption-and-wear classes and instructions for assigning ages to blackbuck skulls. Table 5-2 is a quick reference to use in comparing the material in hand against the key characteristics. The photographic series in Appendix D of a mandible for each class (both radiograph and slanted top view) will assist speedy entry into the lists of classes and give confirmation of identification. Mandibular characters are emphasized because lower jaws are more easily obtained, transported and stored.

Test of wear criteria

Determining an animal's age by the condition of its teeth has been a standard practice among horse dealers for generations (Goubaux and Barrier 1892). In the early 1900's, investigators began describing the eruption changes and then the wear patterns of cervid teeth (Spinage 1973). Later authors have added papers on age-related dental changes for a host of wildlife species, especially ungulates.

The usefulness of these techniques, however, depends on the ease and accuracy with which the models can be applied. Because of variations among individuals, among populations and among workers, results of determining age by wear characteristics are often poor unless year classes are grouped. Lowe (1967) reported 88 percent correct matches for red deer jaws, but Gilbert and Stolt (1970) got only 58.4 percent agreement for white-tailed deer subjected to both wear and cementum count techniques. For mule deer, Erickson *et al.* (1970) got 63 percent agreement using five classes: 2 years, 3-4 years, 5-6 years, 7-8 years, 9 years and older. Keiss (1969) increased his success from 50.2 percent to 83.5 percent by going from 1-year to 3-year age intervals in his classes for his elk tooth wear method. With Uganda defassa waterbuck, Spinage (1967) raised his success of 38 percent with 1-year intervals to 76 percent by accepting the matching year $\pm$ 1. Other ways to increase accuracy are to have samples from all age classes available for comparison (Quimby and Gaab 1957), to have a larger number of skulls for evaluation and to make sure that those using the system are thoroughly familiar with it before starting. Keiss (1969) concluded that the 10 percent error range associated with the experience (1 to 8 years) of biologists testing his method was lower than the error inherent in eruption-and-wear techniques due to variations among animals.

To test the suitability of the criteria set out for blackbuck, 20 wildlife management students (WFS 403) at Texas A&M University were requested to assign ages to 20 blackbuck mandibles. After a brief description of the technique,

TABLE 5-2. QUICK REFERENCE LIST OF KEY CHARACTERISTICS AND ESTIMATED AGES FOR THE BLACKBUCK ANTELOPE TOOTH ERUPTION-AND-WEAR CLASSES.

AGE	CLASS	KEY CHARACTERISTICS
Birth	I	i1 — not yet fully erupted; cutting edge oriented near the vertical pm2 (mand.)[1] — no sign of this tooth yet Other — skull tiny; sutures not all closed yet
1 wk	II	i1 — almost in place or has final orientation, but not fully up pm2 (mand.) — barely above bone Other — sutures still not all closed yet
2 wk	III	M1 (mand.) — cusps 1 and 2 beginning to come through bone (not through gum yet) Other — no signs of wear
3 wk	IV	pm2 (max.)[2] — no wear Other — picking up first signs of wear
1 mo	V	pm2 (max.) — about ½ of occlusal surface worn Other — wear usually just a line (slight to light)
2 mo	VI	M1 (mand.) — cusps 1 starting into wear — secondary cusp not visible yet pm2 (max.) — occlusal surface flat Other — wear broadening
3 mo	VII	i1 — a little wear on it for first time M1 (mand.) — cusps 2 have at least light wear — secondary cusp above bone Other — exposed dentine becoming broad
4 mo	VIII	M2 (mand.) — cusps 1 starting through bone
5 mo	IX	M2 (mand.) — cusps 1 above gum — cusps 2 not out or points just through bone
6 mo	X	M2 (mand.) — cusps 1 light wear — cusps 2 coming through gum
8 mo	XI	M2 (mand.) — cusps 1 light to moderate wear — secondary cusp shows M2 (max.) — cusps 1 through gum with no wear to light wear — cusps 2 above bone or gum without wear
10 mo	XII	M3 (mand.) — cusps 1 through bone but without wear M3 (max.) — in open alveolus or cusps through bone without wear (not through gum)
11 mo	XIII	M3 (mand.) — cusps 1 usually just in wear — cusps 2 out but usually not above gum — secondary cusp not yet above bone
1 yr	XIV	M3 (mand.) — secondary cusp at level of bone or just up M3 (max.) — cusps 1 above bone & sometimes above gum (no wear)
2 yr	XV	M3 (mand.) — secondary cusp somewhat up or well up M3 (max.) — cusps 1 in wear — cusps 2 no wear
3 yr	XVI	Pm3 & Pm4 (mand.) — light wear (infundibulum often present) M3 (mand.) — cusps 2 light wear — secondary cusp usually without dentine showing M3 (max.) — cusps 2 not heavily worn Other — easily confused with XVII
4 yr	XVII	Pm3 & Pm4 (mand.) — not heavily worn; 1 round infundibulum usually on each M1 (mand.) — moderate wear to flattish; clear infundibula between cusps M3 (max.) — cusps 2 light to moderate wear; infundibulum between cusps 2 rarely enclosed Other — easily confused with XVI
5 yr	XVIII	Pm3 & Pm4 (mand.) — worn; usually each has an "infundibulum"[3] (not necessarily round) M1 (mand.) — cusps 1 smooth (or almost) M3 (max.) — infundibulum of cusps 2 well enclosed
6 yr	XIX	M1 (mand.) — cusps 2 smooth (or almost) Other — first class in which zone of postmature growth common at horn bases
7 yr	XX	M2 (mand.) — cusps 1 infundibulum small
8 yr	XXI	M2 (mand.) — cusps 1 smooth

Age	Class	Key Characteristics
9 yr	XXII	M2 (mand.) — cusps 2 smooth
10-11 yr	XXIII	M3 (mand.) — cusps 1 smooth Other — wear uneven
12-13 yr	XXIV	M3 (mand.) — cusps 2 smooth; tooth shape (occlusal view) well defined
14-16 yr	XXV	M3 (mand.) — cusps 2 smooth; tooth shape (occlusal view) not well defined M3 (max.) — very heavy wear Other — some teeth (particularly Pm4 and M1 (mand.)) may be gone

[1]mand. = mandibular.
[2]max. = maxillary.
[3]Because of the way Pm4 folds, there appears to be an infundibulum at this stage of wear. However, this is not a true infundibulum because it is not between cusps in the sense that the infundibula on the molars are.

each student was given an instruction sheet that listed the tooth wear characters. There was no time limit. Fifty-two percent of the determinations matched the age previously assigned on the basis of the cementum counts. Ninety-one percent of the determinations either matched or came within a single year class older or younger. Therefore, the technique was judged satisfactory.

Live observations

To be of maximum value, an observational method of determining the age of animals in the field not only had to be developed but also needed to be related to the system of tooth eruption-and-wear classes.

Field age classes

From observations of live antelope loose in pastures — sometimes with several score animals in view at once — a series of field age classes soon emerged. The major criteria were body proportions, relative size, horn development and coat color. In body proportions, these classes in blackbuck antelope closely approximate the classes defined by Walther (1972) for Thomson's gazelle. Fawns were divided into "brown fawns" (neonates) and "older fawns." The rest of the animals were divided into "adolescents," "subadults" and "adults." Occasionally, "old adults" were also distinguished.

To discover the age limits of these classes, systematic records were kept on known individuals during 2 years of continuous field work. Nine females were watched from birth. One died during its second week; the others were followed from birth to 10 months (one animal), to 12 months (three), to 13 months (one), to 18 months (one) and to 20 months (two). Overlapping each other and the female series were eight males followed from birth to 15 months (one), from birth to 19 months (two), from 8 months to 31 months (two) and from 15 months to 38 months (three). Thus, the younger classes during which changes are more rapid have the best known-age documentation.

Two points not discernable from the tooth eruption-and-wear classes gradually became evident. First, females mature faster than males. From being about 2 months ahead of males at the end of the fawn stage, females attain adult proportions a full year ahead of males. Males continue to fill out, particularly through the neck, and mature at a somewhat larger size and greater weight. As pointed out in Chapter 6, females also reach sexual maturity sooner than males.

Second, social status can affect the body condition of bucks so that, from about 15 months on, an inferior male consistently dominated by one or more other males may look poor. Unless a changing social situation releases him from his inferior position, such a buck never fills out completely and never develops the full male thickening of the neck. These relationships between social status and body condition must be held in mind when evaluating proportions during classification in the field. Fortunately, horn growth does not show these pronounced differences with social status; thus the horns are a reliable index even when general body condition might cause confusion.

During the period of this study, horn development was quite predictable among the

TABLE 5-3. DEVELOPMENTAL COMPARISON FOR LIKE-AGED BUCKS IN TWO DIFFERENT SOCIAL SITUATIONS FROM BIRTH TO SUBADULT AGE CLASS.

AGE (mo)	RANCH A One ♂ without ♂ age-mate	RANCH B One pair of bachelor companions
0	Pigmented areas brown	Same
1	Start to lose brown color	Same
2	Coat yellowish	Same
3	Horns only visible under ideal conditions; coat pinkish	No horns actually seen
4	Horns visible as two bumps on forehead contour	Horns same; coat pinkish
5	Horns easily visible but very small	Same
6	Coat same color as adult females	Same
7	Horn tips up	Horn tips barely up; horn length 1/2-1/3 ear length
8	Horns curve up noticeably but no twisting yet	Horn shape same; horn length about equal ear length
9		Body filling out noticeably
10	Horn tips up and out; 1/3 of horn length annulated	Horn shape same
11	Horns still up and out but body nearly subadult	Same
12	Horn tips barely back and out; body subadult proportions	Same
13	Horn tips back and out	
14	Horn tips up and out	Horns have 1 2/3 twists
15	Horn tips back and barely in; horns have 1 2/3 twists	Horns have 1 3/4 twists; superior companion darker tan while inferior companion still unchanged
16	Coat shows some darkening	Horns have 1 3/4 twists; superior companion pepper colored while inferior companion still unchanged
17	Horns have two twists; coat pepper colored; first true mating observed	Superior companion continues to darken
18		Superior companion a darker pepper color while inferior companion light pepper on ventral neck
19	Horn tips up and in; horns have two twists	Horns have two twists; no behaviorally complete mating observed yet

known-age males in the Hill Country. Table 5-3 shows the close correspondence in horn development for three males on two different ranches over approximately the same period. The early coat changes characteristic of fawns of both sexes were also equivalent. During the second year, however, the inferior buck showed later and less development of dark hair color than its superior companion, illustrating that the coat darkening characteristic of males is unreliable as an indicator of age. Factors affecting coat darkening in males are discussed in Chapter 7.

Following are descriptions of the age and sex classes used in the field. The differences between classes are more subtle than for the tooth eruption-and-wear classes, but the observer who is once familiar with them can apply them at a glance. For approximate age of each class, see Table 5-2.

Brown fawn (Figs. 5-2 and 5-3): The neonate blackbuck is brown over the pigmented areas rather than an orange-tan like adult females and most immature males above the fawn stage. Into the fawn's second week, it is still shorter at the withers than the bottom line of its mother's belly. By 2 weeks of age, the fawn has lost its neonate proportions (long legs, thin body, body

FIG. 5-2. Adult female with her young fawn who still has the brown color of a neonate ("brown fawn").

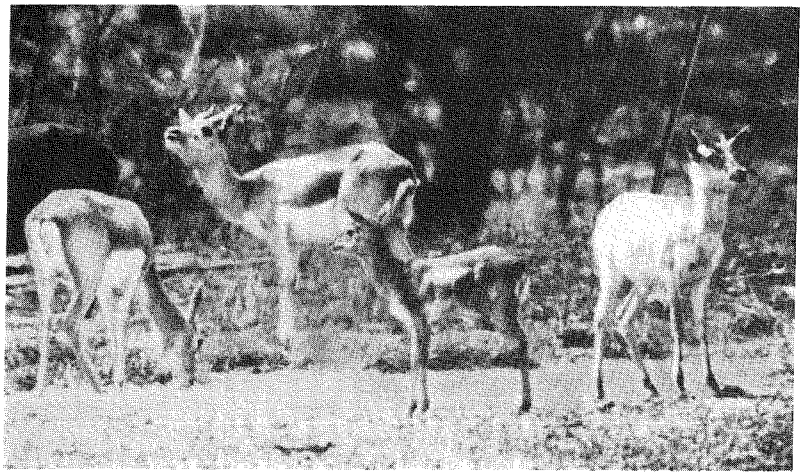


FIG. 5-3. Older male fawn (right) standing near a brown fawn (second from right), an adolescent male (third from right) and a female.

not very deep) and is well coordinated. It is growing fast.

Older fawn (Fig. 5-3): At about 1 month of age, the fawn's coat changes to approximate that of the adult females. The fawn's withers now overlap its mother's side. The coat takes on a light, creamy yellow color at from 1.5 to 2 months and then gains a pinkish cast by 2.5 to 3 months before it finally assumes the typical orange-tan. With good visibility, bumps can be spotted on the head of males as early as 4 months.

Adolescent (female, Fig. 5-4 right; male, Fig. 5-5 middle): The adolescent has exchanged the long legs, short body and short neck of a fawn for a longer, deeper body which makes the legs appear relatively shorter and the neck longer. The coat is now the typical orange-tan. The withers come well up on an adult female's side, but the adolescent is still shorter in both height and length. Males continue to grow more robust horns; these curve forward, start to grow rings and begin to spiral.

Subadult (Figs. 5-5, 5-6): Subadults are as tall as adults (or almost) and as long but not as deep through the body. Therefore, they are lighter in build than adults. The face is still shorter than that of a fully adult animal. Viewed in broadside position, the white along the side of females is less wide than the pigmented area. When distances are great or when visibility is poor, distinguishing subadults of either sex from adult females

FIG. 5-4. Adolescent female.

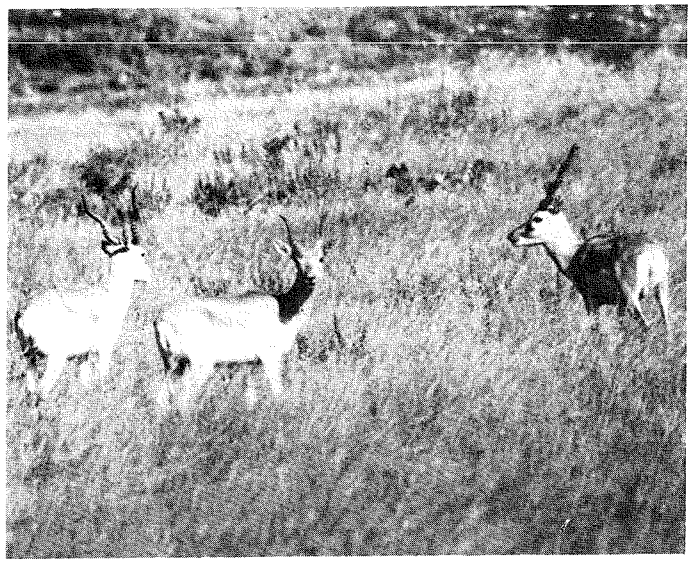


FIG. 5-5. Three bachelor bucks: (left to right) subadult, adolescent, adult.

quickly becomes impossible, Unless constantly dominated, subadult males quickly start to develop a thicker neck than females. Characteristically, the horns have two twists with the tips pointing in when males reach the subadult stage and have three twists with the tips pointing in when adulthood is reached. This is the youngest class in which males may start to turn dark.

Adult (Figs. 5-2, 5-5, 5-6): Fully adult animals are deep through the body and have longer faces than subadults. The width of the white on the side approximates that of the pigmented area. Females often have some darkening on the lower shoulder where the pigmented area borders on the white, on the upper forelegs and on the stifle. Males may be orange-tan, black or any color in between, regardless of their age. Their horns have anywhere from three to five twists (seldom fewer or more). Old adults have a sagging underline to the body, which remains deep but looks more oblong than square between elbow and stifle. Old males who are dark may show conspicuous gray mixed into the coat on the pigmented areas of the head.

Test of correlation between field classes and tooth classes

To test the two aging methods against each other, a sample of 100 carcasses from the Edwards Plateau were classified according to the field aging criteria. After the skulls were cleaned, the teeth were evaluated according to the tooth eruption-and-wear criteria. The results agree well. As Table 5-4 shows, females advance to older field classes at younger tooth-wear ages. This reflects the earlier maturity among females. Also, the tooth eruption-and-wear classes assigned ages of 1 year and 2 years appear on the appropriate borders of the sex and age field classes. The field classes do not allow nearly as many year classes to be distinguished as the tooth classes do, but the field classes can be used with at least the same accuracy.

Horn growth

In pastures and periods for which horn growth patterns have been established, horn size and shape can be used as an age indicator for immature bucks, as Table 5-3 demonstrates. For whole regions and over long periods, however, applications become more approximate. In the total Hill Country sample of skull material there is considerable overlap of both horn lengths and shapes among the immature classes.

Within these broad limits, horn development appears the same in both Texas and India, for Bristow's (1925) comments on a captive Indian buck of known age indicate that visible

TABLE 5-4. CORRELATION OF AGE WITH AGE CLASSES. TOOTH AGE CLASS (ROMAN NUMERAL) AND FIELD AGE CLASS (DESCRIPTIVE PHRASE). NOTE THAT FEMALES ADVANCE TO OLDER FIELD AGE CLASSES AT YOUNGER TOOTH AGE CLASSES.

MALE CLASSES	AGES	FEMALE CLASSES
I Brown fawn	Birth	I Brown fawn
V Older fawn	1 mo	V Older fawn
	4 mo	VIII Adolescent
IX Adolescent	5 mo 6 mo	X Subadult
XIII Subadult	1 yr	XIV Young adult
XV Young adult	2 yr 3 yr	XVI Fully adult
XVII Fully adult	4 yr	
XIX Old adult	6 yr	XIX Old adult
XXV	16 yr	XXV

horn growth commences at a comparable age in both areas. Berwick's (pers. comm.) Indian data on two captive males shows a linear rate of increase in length for at least the initial 14 months. This is supported in the Texas data by the observation that "submature growth checks" (Simpson 1971) of the type used to determine age in certain other bovids do occur in blackbuck but not with the reliability and clarity necessary to establish age. Bristow's (1925) observations on the number of twists attained by adults in India's Central Provinces agree with the data now available for Texas.

The horns continue to spiral after maturity, but the growth rate slows rapidly. Between 2.5 and 3 years the horns of typical bucks attain the species-specific form of at least three twists (a few never quite complete the third twist) and at least 330 mm (13 in) length, measured in a straight line from lowest anterior horn base to tip. In another 6 months the horns often make another third to half turn. By class XIX or, at most, class XX, horn discontinuities like stacks of rings are beginning to pile up at the base, forming a zone of what Simpson (1971) calls "postmature growth checks" for various African bovids exhibiting this phenomenon. Reach-

FIG. 5-6. Subadult female (left) playfully pushing her head against that of an adult female who accepts the challenge seriously.

ing class XXI some horn cores are nearly closed at the distal end while others remain patently open, even in males of the oldest class.

The common assumption that older bucks have longer horns is only true in part. The individual variation evident among the immature males carries over into the adult category as the general growth rate slows after maturity. Until the incidence of splits and breaks becomes significant in class XIX, the males with the longest horns as immatures are likely to be the males with the longest horns as adults. However, splitting and wear in old age can result in class XXIV horns being little bigger than the maximum for class XVII. Also, maximum horn length by class XIX at the oldest can equal or even surpass the maximum lengths observed for any of the older classes. For example, the greatest measurement for class XIX was 484 mm (19.06 in), whereas the greatest for any of the older classes was 474 mm (18.69 in) in class XXV. A few exceptional Hill Country horns do exceed 508 mm (20 in). One adult in the Texas sample of 526 blackbuck had 584 mm (23 in) horns. However, none of the 501 specimens that could be assigned an age falls into the 508 mm (20 in) to 590 mm (24 in) range.

Adult horns with more twists are not necessarily from older bucks either. Blackbuck can attain minimum adult horn length at 1.5 to 3 twists. Animals with a particualrly open spiral may never develop more than three twists even in advanced old age, while bucks with a tight spiral can reach five twists by class XIX (see also the section on horns in Chapter 2).

Summary

The ability to determine the age of animals increases the effectiveness of programs designed to manage them. Two different methods are required for blackbuck: one for live animals which does not necessitate physical contact and one for skull material which does not involve the rest of the carcass.

Twenty-five age classes based on tooth eruption and wear cover the period from birth through the maximum recorded longevity. Although each of the five major field age classes includes several tooth age classes, the groupings correlate well. However, it must be remembered that the border classes for females differ from those for males because the females mature faster. Coat color is not a reliable index of age for animals past the fawn stage.

Neither horn length nor number of horn twists can be used as age criteria once bucks approach the minimum adult dimensions of 330 mm (13 in) length and three twists. Even though the horns of adults continue to grow and spiral, the rate slows rapidly after maturity. By tooth class XIX (about 6 years), maximum observed horn length can equal or surpass that of older classes. In class XIX, horn splitting and breaks become much more frequent, and in class XX (about 7 years), tip wear can shorten horns noticeably. Therefore, length increases due to advanced age can be cancelled. Within the adult range of 2 to 5.5 twists, the number depends more on individual variation in the tightness of the spiral than on age.

(Robert W. Spain contributed to Chapter 5.)

6

REPRODUCTION/POPULATION

☐ Natality rates, mortality rates and all their related aspects combine to determine the dynamics of a population. The factors act to give a population a certain age and sex composition. If this composition remains unchanged, then the population structure is said to be stable. In an expanding population, natality is greater than mortality; in a declining population the reverse holds true. In husbanding a population, the wildlife manager also assesses productivity, which is a result of this dynamics as it operates through time. By indicating trends, a comparison of figures aids predictions for a cohort as it advances into future age classes. Applications for the management of hunted populations are discussed in Chapter 12.

To depict a population and its workings over time, it is necessary to analyze the attributes of the individuals that make up the population. This chapter begins by examining the reproductive characteristics of blackbuck, their breeding habits, their maturation patterns and their survival potential.

Reproduction

The reproductive process begins with the behavioral mechanisms that bring male and female together (see Chapter 4). Even after a sperm successfully fertilizes an ovum, however, there are many complex steps to be negotiated before a live young can be produced and reared.

Chromosome complement

The diploid chromosome number is 30 in the blackbuck female and 31, occasionally 33, in the blackbuck male (Effron 1976). The difference in the male can be explained by Robertsonian fusion, a process common among gazelles (Effron 1976; see section on similarity to gazelles in Chapter 8). The difference between the

male and female numbers is due to an X-autosome translocation whereby an autosome has become attached to the X chromosome, thus giving the female two particularly large X chromosomes and the male one particularly large X chromosome, one regular Y chromosome (Y1) and one autosomal Y chromosome (Y2); the Y2 chromosome shows G-banding homologous to the ends of the longer arms on the X (Effron *et al.* 1976).

Sex determination follows the basic mammalian pattern of XX female and XY male, except that the male blackbuck is XY1Y2. It is tempting to speculate that the translocation which made the X so unusually large and which resulted in this XY1Y2 variation (Wurster *et al.* 1968, Effron *et al.* 1976) was what linked coat color so permanently with sexual characteristics. Of more than 40 other artiodactyl species studied, the only other one with a similarly large X is the sitatunga (Wurster *et al.* 1968) in which uncastrated males also exhibit a sex-related color change (see Chapter 7).

Male reproduction system

The reproductive tract of the blackbuck male is generally similar to that of a domestic ram or a domestic bull. Fig. 6-1 shows the testes and the penis of the blackbuck partially dissected. The two testes lie within the scrotum which has a covering of short hairs like those of the surrounding ventral surface in color and type. The opening of the prepuce or sheath is anterior to the scrotum along the midline of the abdomen. The end of the sheath is often visible in side view, with the opening, as in the ram, being at a sharp angle to the relaxed penis. There is no tuft of preputial hairs, and the sheath is not as greatly elaborated as in the bull. Like the bull, the ram and the boar, but unlike the stallion, the blackbuck male has a fibro-elastic penis which is extended, but only slightly enlarged, when engorged with blood during sexual excitement. In the relaxed state, the retractor penis muscles contract and hold the penis within the body by drawing it into an S-shaped curve.

As in the domestic bull, the glans penis tapers and has a terminal longitudinal groove along one side. As in the ram, the oriface of the urethra is carried farther by a filiform appendage, the *processus urethrae* (Fig. 6-1). In blackbuck this somewhat flattened appendage lies

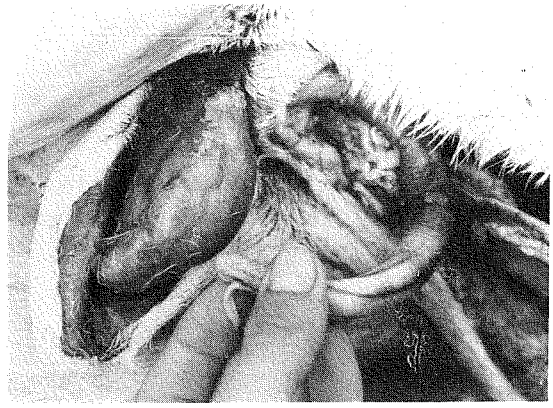
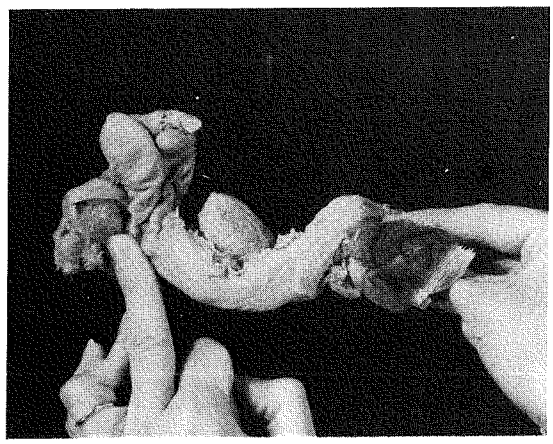


FIG. 6-1. Blackbuck testes and penis partially dissected. Note filiform appendage and the groove in which it lies at end of penis.

FIG. 6-2. Reproductive tracts of immature (above) and mature (below) blackbuck females. Inner surface of one horn (below) is exposed to show wrinkled structure of open adult tract.



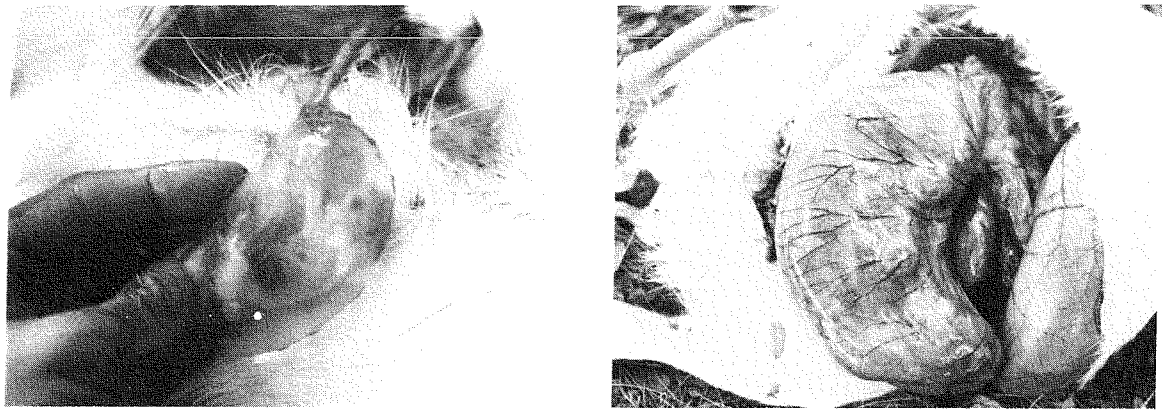


FIG. 6-3. Blackbuck embryo with cotyledons just beginning to form (left) and fetus near full term showing outline of some of the placentomes (right). Note orientation of fetus within body cavity.

along the terminal groove. During ejaculation the ram's filiform appendage spins about spraying semen along the external opening of the uterus (Blom 1968).

The average adult testis weight (Fig. 6-1, left testis measured) of 19.9 gm (0.70 oz), with a range of 8.6 to 29.6 gm (0.30 to 1.04 oz), calculated for 21 Texas bucks compares favorably with the 13.0 gm (0.46 oz) example cited by Knepp (*in* Asdell 1964). Knepp's material showed a seminiferous tubule length of 704 m (770 yd); the length of the individual spermatozoon was 48.4μ.

Female tract and fetal development

The reproductive tract of a blackbuck female resembles that of a domestic ewe or a domestic cow, except that the uterus is bicornuate (Abromavich 1930) rather than bipartite. In all three species, the uterus is suspended from the pelvic girdle by the broad ligament so that the uterine horns circle in a smooth curve down, back and then up again so that one spherical ovary is to each side of the uterine body. Before sexual maturity both horns and body of the uterus are small and narrow (Fig. 6-2A). After maturity they are larger and fuller and have a wrinkled inner surface (Fig. 6-2B).

Placentation is of the cotyledonary, syndesmo-chorialis type. In the early stages of pregnancy the fetal membranes surround the embryo like a small balloon. At the stage when the precursors of the cranial sutures are evident, the ears are forming, all eight hooves can be distinguished, the ribs, tail and eyelids are distinct, crown-rump distance is nearly 50 mm (2 in), and pink spots have formed on the chorion, indicating that cotyledon development and implantation are imminent (Fig. 6-3A). At this age the embryonic sac has not yet expanded enough to extend into both uterine horns. At 124 mm (4.9 in) crown-rump distance the allantochorion occupies both horns but the amniotic sac is still confined to the horn where the fetus actually lies; by now the horn containing the fetus has enlarged and the cotyledons have joined with the maternal caruncles to create placentomes (Abromavich 1930).

The placentomes form by localized degeneration of the epithelium of the uterus; this leaves highly vascularized endometrial connective tissue contacting the epithelium of the chorion which is underlain by the endothelium of the fetal capillaries. This fetal segment then invades the maternal portion, resulting in round patches of fetal villi secured within maternal crypts. Through these placentomes, the growing fetus obtains from the mother the nutrients needed to sustain life and growth. Abromavich (1930) counted 96 cotyledons, some concave and others flat, on the placenta of a 124 mm (4.9 in) fetus: 54 in the gravid right horn, 42 in the nongravid left horn, none attached to the uterine body. As is characteristic among bovids, most of the fetal cotyledons are concave (Abromavich 1930). By full term, the range of placentome sizes has increased to roughly 15 mm (0.6 in), characteristic of the placentomes in the nongravid horn, to 60 mm (2.4 in), characteristic of those in the gravid horn.

Tiny, nearly circular depressions in the maternal epithelium — the mouths of the uterine glands — are scattered irregularly over the intercotyledonary area of the uterus. Abromavich estimates their density at 375 per 64.5 mm^2 (375 per in^2). (Abromavich 1930).

Like Abromavich's (1930) fetus, all five of the implanted fetuses for which the side of the gravid horn was recorded during the Texas study were on the right. Two completed pregnancies for which the side appeared evident had also been on the right. The only record for the left horn was a 30 mm (1.2 in) embryo that had not yet begun to form cotyledons. Considering that all of 69 pregnancies in Thomson's gazelle for which Bradley (1977) recorded the side were on the right, the fetus on the right may be the typical blackbuck pattern as well.

As it nears full term, the fetus comes to rest comfortably coiled with its back to the dam's rear and the head facing to the dam's front on her right near her rib cage (Fig. 6-3B). The fawn's head is turned to its left so that it points upward. The forelegs are tucked and sometimes also turn upward. The hindlegs are either well tucked or half tucked and thrust upward into the viscera.

Milk production

Mammary tissue starts to proliferate before milk appears. Adolescent females have virtually no mammary development. Open adults show a moderate amount. Lactating adults have enough for the udder to be clearly visible when the female is viewed from behind. The udder has two teats, one for each half.

TABLE 6-1. GROSS COMPOSITION OF BLACKBUCK MILK COMPARED TO THAT OF CERTAIN OTHER UNGULATES. NUMBERS SHOW PERCENT IN SAMPLE OR SAMPLES; FIGURES IN PARENTHESES INDICATE RANGE OF VARIATION.

Species (Reference)	# Animals	# Samples	Period covered	Total solids[1]	Fat	Solids-not-fat[2]	Protein[3]	Lactose
Blackbuck (Dill *et al.* 1972)	3	3	Unknown stages	20.8 (19.5-22.4)	9.3 (7.8-11.2)	11.6 (11.2-11.8)	6.9[4] (6.8-7.0)	4.3 (3.6-4.8)
Grant's gazelle (Ben Shaul 1962)				34.1	19.5	14.6	10.4	2.8
Thomson's gazelle (Ben Shaul 1962)				34.2	19.6	14.6	10.5	2.7
Mountain gazelle (Ben Shaul 1962)				36.1	19.0	17.1	12.4	3.3
Impala (Ben Shaul 1962)				35.3	20.4	14.9	10.8	2.4
Springbok (van Zyl and Wehmeyer 1970)	1	26	Whole lactation	21.9 (17.1-27.2)	8.9 (5.2-13.3)	13.0 (11.9-13.9)?	8.0 (5.5-11.5)	4.8 (3.9-5.2)
Pronghorn (Einarsen 1948)	1	1		24.9	13.0	11.9	6.9	4.0
Eland (Treus & Kravchenko 1968)	> 9?	51	Probably several whole lactations included	21.8 (19.7-23.3)[5]	9.8 (8.2-10.9)[5]	12.0 (11.5-12.4)[5]	12.7 (11.7-13.4)[5]	3.9 (3.5-4.4)[5]
Chinese water buffalo (Wright *et al.* 1939)	30	frequent	18 mo interval	23.2	12.6	10.6	6.0	3.7
Domestic cow (Wright *et al.* 1939)	130	1,998	198 whole lactations	13.8	4.4	9.3	3.8	4.9
Evaporated cow's milk (Silver 1961)				26.2	7.9	18.3	7.0	9.8
Domestic goat (Wright *et al.* 1939)	≥ 326		Values from 18 investigators summed	12.9	4.1	8.8	3.7	4.2
Evaporated goat's milk (Miracle Brand — information on can)				25.5	7.9	17.6	7.4[6]	8.4[6]

The Indian emperor Jahangir (1909) reported that an antelope he had a chance to milk gave four seers a day and that the milk was just like that of the cow and of the buffalo. The blackbuck milk collected during the Texas study also looked and smelled like fresh cow's milk except for being whiter in color; the extracted fat also lacked the yellow tone characteristic of fat from cow's milk (Dill *et al.* 1972).

Among three Texas samples, the fat content varied noticeably (Table 6-1), while the percentage of other solids remained fairly constant (Dill *et al.* 1972). Studies on eland antelope (Treus and Kravchenko 1968) demonstrate that, even though the milk changes rapidly in the initial 3 to 4 days post partum from the colostrum of the first day to a "normal" consistency, there are still composition shifts from month to month (Table 6-1). Although the timing and the patterns of change differ from one species to another, all studies over sufficiently spaced portions of the lactation cycle show composition changes with phase of lactation. At least in dairy cattle, fat and protein percentages are particularly subject to individual variation as well (Wright *et al.* 1939). Accurate fat evaluations are especially difficult because of several factors not as important for protein lactose determinations. Fat content changes with time of day, with stage of depletion of the udder during any given milking or nursing and with section of the udder emptied (Wright *et al.* 1939).

As can be seen from Table 6-1, cow's milk does not closely approximate blackbuck milk. Compositional discrepancies often lead to digestive problems in deer fawns raised on whole cow's milk, so a number of modified formulas

Species (Reference)	# Animals	# Samples	Period covered	Total solids[1]	Fat	Solids-not-fat[2]	Protein[3]	Lactose
Domestic sheep (Wright *et al.* 1939)	2	regular intervals	Whole lactations	17.1	6.2	10.9	5.4	4.2
Dall's sheep (Cook *et al.* 1970)	7	7	0.75-6 mo at various stages	27.5 (20.9-42.8)	12.0 (8.0-20.6)	15.3 (10.7-22.2)	9.2 (5.7-13.1)	4.7 (2.5-6.6)
Bighorn sheep (Chen *et al.* 1965)	5	5	about 1-1.5 mo and about 3 mo	24.1 (14.3-35.3)	10.4 (4.0-16.1)	13.6 (10.3-19.2)	7.9 (4.3-13.6)	4.5 (2.7-5.3)
Mountain goat (Lauer *et al.* 1969)	2	2	about 1.5-2 mo and about 4 mo	29.9 (21.2-38.7)	11.7 (5.7-17.7)	18.2 (15.5-21.0)	14.7 (11.4-18.0)	2.2[7] (1.6[7]-2.8)
Reindeer (Aschaffenberg *et al.* 1962)	5	8	3-16 d and 3.25-4 mo	27.6 (22.2-33.1)	13.0 (9.2-16.9)	14.6 (13.0-16.2)	9.3 (7.2-11.5)	3.3 (2.8-3.9)
Sika deer (Ben Shaul 1962)				36.1	19.0	17.1	12.4	3.4
Red deer (Arman *et al.* 1974)	4	100	Whole lactations	23.9 (21.1-27.1)[8]	10.6 (8.5-13.1)[8]	13.3 (12.6-14.0)[8]	7.8 (7.1-8.6)[8]	4.4 (4.4-4.5)[8]
Fallow deer (Jenness and Sloan 1970)	1	1		25.3	12.6	12.7	6.5	6.1
Black-tailed deer (Kitts *et al.* 1956)	2	3	2 at 28 d and 1 at end of lactation	25.0 (24.5-25.4)	10.4 (10.2-10.5)	14.6 (14.3-14.9)	8.9 (8.1-9.6)	4.4 (3.9-4.7)
White-tailed deer (Silver 1961)	1	4	2 d, 1 wk, 1 mo and 5 mo (end of lactation)	25.2 (22.2-33.5)	10.4 (7.5-18.0)	14.9 (14.2-15.5)	10.3 (8.8-11.5)	3.0 (2.2-3.8)

[1]Water content is calculated by subtracting total solids percentage from 100.
[2]This is the difference of total solids minus fat. Solids-not-fat includes a small amount of "ash."
[3]Protein content usually calculated as nitrogen X 6.38 even though the applicability of this factor has not been tested for many of these species.
[4]Protein reported for only two blackbuck samples.
[5]Eland ranges are for monthly averages; protein range is uncertain because one casein value is missing.
[6]Estimated from whole-milk values given by Wright *et al.* 1939.
[7]This value could be low due to lactose fermentation.
[8]Red deer ranges for stage averages: 3-30d, 31-100d, > 100 d.

have been developed for cases where a cow's milk base is used (Murphy 1960, Silver 1961, Wood *et. al.* 1961). Because of the problems with the cow's milk diet, it has been suggested that — of the kinds of milk available bottled, canned or from domestic milch animals — goat's milk would be a better choice for hand-raising a blackbuck fawn (Ramsey pers. comm.). The more closely any milk approximates the species composition, whether naturally or modified, the greater the changes of rearing an orphan fawn successfully.

Similarity of milk composition appears to follow similarity of habitats and habits more than closeness of taxonomic position (Ben Shaul 1962). For example, in Table 6-1 the sika deer fits better with the three gazelle species than with the rest of the Cervidae listed. Water buffalo and domestic cattle are in the subfamily Bovinae, but various sorts of water buffalo differ and all are even farther from the domestic cow (Wright *et al.* 1939). Animals such as Dall's sheep, bighorn sheep, mountain goat and reindeer that face cold environments tend to produce concentrated milk high in fats. Others like blackbuck, pronghorn and white-tailed deer that nurse their young only during brief, widely-spaced care periods also yield concentrated milk with much fat (Ben Shaul 1962). This is logical, since the satiety value of fat exceeds that of any other milk component (Ben Shaul 1962).

Lack of twinning

Blackbuck give birth only to single fawns. There were no twins among the combined total of 338 births at the San Antonio Zoological Gardens & Aquarium (Roney pers. comm.), the London Zoo (Jarvis and Morris 1961) and the New York Zoological Park (Doherty pers. comm.). Although like-aged fawns were frequently seen together during the Texas study, whenever they could be observed for an extended period they proved to be "companions" (Mungall 1977) rather than twins. From 2-3 weeks of age to 2-3.5 months, fawns tend to pair off; they lie together, play together and often follow the same doe. However, the doe will nurse only her own fawn. The other companion must find its own mother in order to suckle. The "twins" referred to in the literature (*i.e.* Lydekker 1907, Brander 1923) are most likely examples of this "companion effect" (Mungall 1977).

Length of receptive period

The receptive period during the blackbuck female's estrous cycle lasts about 24 hours (Taibel 1937, Backhaus 1958). As in Schmied's (1973) Austrian herd, Texas females bred one day were frequently still in heat the next day and were sometimes bred again, although courtship during the second daylight watch was less intensive. Typically, the Texas females were seriously courted four times during the daylight portion or portions of estrus. The last session was often less vigorous and did not always include mounting; peak receptivity had passed.

Female groups make a daily circuit involving contact with several mature males. For example, one female group in a large pasture traveled approximately 5.5 km (3.4 mi) each day through a potential use area of 66 ha (162 ac). This brought them through or near 12 territories (as described in Chapter 3). If the total area had been taken up with territories of average area (4 ha; 10 ac) or average maximum dimension (170 m; 558 ft), then the females would pass 16 territories even if they retraced their steps exactly when returning to repeat the circuit. Especially when using narrow valleys, groups commonly do use the same routes both going and coming.

Therefore, chances are good that a doe will be bred during her receptive period. One buck may be absent and the next may already be courting another doe, but as an estrous female travels with her group, several bucks are likely to detect her condition. Of these, most will probably be physiologically compatible with her. The recurrent contacts increase the likelihood that the female will be bred at the most advantageous time for conception. Even in a small pasture where only one buck has access to a female group — regardless of how many males are actually in the enclosure — this one buck will initiate courtship at intervals throughout the day. Because of the short life span of sperm and ovum, and because the sperm in many species need time for capacitation within the female tract before they can fertilize, timing is important (McLaren 1968). For the domestic

cow, with ovulation approximately 14 hours after estrus, the best time for breeding is soon before the end of estrus. For the ewe, with ovulation soon before the end of estrus, the conception rate is highest with mid-estrus breeding. The observed behavior in blackbuck suggests a pattern similar to that of the ewe.

Since the daily circuit of a female group stays basically the same for weeks even though minor variations mean a male or two visited one day may be excluded the next, a receptive period longer than 24 hours might actually be disadvantageous. It would divide the attentions of the breeding buck among a larger number of animals when receptive periods overlap. Because the female groups are within some territories for only a few minutes, the more females in heat at once, the less effective a territorial buck can be.

Breeding and breeding back

Gestation in the blackbuck lasts about 5 months. Data are often presented in favor of a 6-month gestation period (Brown 1936, Taibel 1937, Schmied 1973), but these are difficult to evaluate. Sometimes no clear distinction is made between reproductively effective and reproductively ineffective types of mounting. Intromission and conception are no more synonymous than are mounting and copulation. The observation that the doe at the experiment station at Rovigo, Italy, attracted the buck's notice the day she gave birth and that mounting was seen (Taibel 1937) does not imply effective breeding. The blackbuck's cotyledonary placenta implies that the female cannot conceive again so soon. Instead, such cases are probably the result of the increased estrogen production associated with birth; as during heat, estrogen levels are high at parturition. A Texas buck who had more females present than the Italian male was seen chasing one particular female relentlessly shortly before the group settled for a rest period and one of the females gave birth. After the rest period he passed the new mother closely without any visible reaction and took no notice as he grazed out of sight with the rest of the group leaving her behind.

Analogy with the domestic cow demonstrates why the fawning interval cannot be construed as the gestation length. Times are longer for the cow, but the steps are the same. The domestic cow has a cotyledonary placenta like the blackbuck's but a longer gestation period of about 9.5 months. After parturition, the cow requires 30 to 50 days for involution of the uterus (Lasley 1968). Invading leucocytes clean up the debris; new epithelium grows over the wounds where caruncles hemorrhaged when the cotyledons pulled away; the myometrial muscles start drawing the uterus back to normal size. After a month, the uterus has almost recovered; it has regained the tone normal for an open female, although it is still somewhat enlarged. In another 10 to 20 days, a cow receiving an adequate diet will begin to cycle. However, the second cycle (at about 60 days in the cow whose first estrus comes at 40 to 50 days) is a more favorable time for conception because the uterus has now completed involution. Low nutritional level can retard the resumption of estrous cycling (Lasley 1968).

Each full estrous cycle takes 5 to 6 days in the blackbuck (Taibel 1937). Schmied (1973) noted recycling in 7 to 21 days, but only if fertilization did not occur during the first heat after paturition; however, his animals were sometimes difficult to observe closely. Regardless of season, females continue to cycle until bred (Taibel 1937, Schmied 1973).

Typically, lactation and development of the new embryo go on simultaneously. In Texas field observations, the frequency with which one sees a fawn about 2 to 4 weeks old with a doe that a territorial buck is tending assiduously suggests that the female starts to cycle again 2 weeks after giving birth and is actually ready for conception in another 2 weeks. The data from the Italian experiment station (Taibel 1937) are consistent with this interpretation. Nevertheless, Schmied's (1973) observations imply that, at least under certain conditions, milk production may initially have an inhibitory influence on resumption of estrous cycles; mothers with fawns were seen in heat at the earliest 12 weeks after parturition, but mothers who lost their fawns were usually seen in heat again after about 10 to 15 days. If the loss occurred at or within a few days of birth, however, the mothers were bred again soon after (Schmied 1973).

The average blackbuck fawning interval is 6 months. If one allows for the short (about 10 to 15 days) separations from the buck at the

time of fawning, an adult at the Italian experiment station held this schedule almost to the day for four consecutive births and then skipped only 5 months before her next fawn (Taibel 1937). One female offspring of this animal was much more irregular when starting her career as a mother. There was a 9-month interval between her first and second fawns; her subsequent intervals were about 7 months, almost 8 months and about 9.5 months (Taibel 1937). Loder (1894) recorded fawning intervals of 7 months and 5 months 1 week for two different females. The latter time approaches the minimum. Schmied's (1973) data from the Austrian experiment station also show the variability among individuals and for the same individual; the average time between births was 180 days (6 months) with both the maximum of 191 days and the minimum of 173 days shown by the same animal.

Population dynamics

Having examined the individual, the next step is to understand the effect produced when such individuals are considered collectively. Population characteristics tend to take the form of peaks, rates and averages.

The question of a rutting season

The blackbuck does not have a seasonal rut in the sense that temperate-zone ungulates characteristically have. Instead, there tend to be seasonal highs and lows in general activity (see Chapter 4). These probably reflect the effects of variations in physical condition, vegetation availability, food value of plants and daily temperature ranges. The Duke of Bedford and E.H.A. Marshall (1942) note that tropical-zone species are likely to maintain an unchanged breeding pattern when moved to the temperate zone, whereas temperate-zone species may either lose their synchrony or maintain their former pattern when moved to the tropics, or they may switch to match the reversed seasons if relocated to a temperate area in the opposite hemisphere.

Schaller (1967) defined two rutting peaks in India. The minor one in March-April comes during the first half of India's summer when some of the grown bucks are tan and when food is less plentiful although not yet at is lowest. The major one in August-October comes during the last half of the monsoon when most bucks turn dark and when vegetation is at its best. Because of phenological differences from one locality to another, as well as from one year to another, early authors recognized increased activity anywhere from January to April, with March being mentioned most often (Elliot *in* Jerdon 1874, Baldwin 1876, Brander 1923, Stockley 1928).

But what are these "rutting" peaks? As defined by the authors themselves, the peaks are highs in the frequency of such behavior patterns as displaying, mounting and chasing which can be behavior associated with courtship. What makes this definition untenable is that such patterns are also used in nonsexual contexts. In order to use this definition, the situation in which each of these behavior patterns is employed in each instance must be analyzed. Suppose a buck paces in display toward a doe who has her head down eating. She moves ahead, but this would be her response in either a sexual or a nonsexual case. Now the buck lowers his head and eats where the doe had been. Is it a case of the buck losing interest in the doe and subsequently focusing on the food, or was it his object from the beginning to displace the doe from that feeding spot?

It would be a more practical approach to count close courtship sessions; in these a buck is focusing his attention on a receptive doe. The seasonal distribution of close courtship sessions does not necessarily match that of displaying. In a small pasture studied for 2 years, summer had the second highest frequency of observed close courtship sessions, slightly less than half the number observed in the fall. During the same 2 years, however, the number of observed interactions involving display of the type that can be used in courtship was lower in the summer than at any other season. As pointed out, the display totals include many interactions with no direct sexual overtones, and, even when directed by a buck to a doe, much routine displaying in the nose-lifted posture (see Chapter 4) seems merely to be the way a male initially checks the receptivity of females to which he has access.

If enough close courtship sessions can be observed to indicate any trends, then calculated

peaks in rutting behavior reflect peaks in the number of estrous females present. This is because the blackbuck male is reproductively active all year and the female can come into heat at any time of year (Taibel 1937, Hediger 1949, Etkin 1954, Backhaus 1958). Working with Indian fawning observations and a 6-month fawning interval, Schaller (1967) estimates that the conception rate in India is highest from August into October. This is reasonable, since during the latter part of the monsoon and into early winter, vegetation is most abundant and most nourishing (see Chapter 9) and the female's condition should be at its best. Schaller's (1967) figures rank the early summer rut generally recognized in Indian accounts as a lesser conception peak. Vegetation quality is deteriorating, but females bred during the late monsoon and early winter are then giving birth and coming back into estrus. Brander (1923) summarizes the situation by stating that blackbuck throughout India are in "rut" during all of the time of cold weather and locally at any time except during the hot weather period.

Fawning peaks

Fawning peaks, such as they are, are seldom pronounced. Several authors comment that fawns are born in all seasons in India (Elliot *in* Jerdon 1874, Sterndale 1884, Brander 1923), but few comment on whether births are more common during particular periods. Brander (1923) is an exception; he states that most births occur soon before the rains. As discussed earlier, Schaller (1967) postulates that for the Indian locations he visited there is a fawning peak which coincides with each of two yearly activity peaks among the bucks, in March-April and in August-October, and that more fawns are born during the second.

In Texas fawns are also seen all year. There is a low in winter but distinct peaks are not evident except after particularly extreme winters. Severe winterkills can remove all fawns and adolescents from some pastures. In addition, there is an increase in the incidence of miscarriage and death among females due to give birth before spring rains bring new forage growth. However, this synchronizing effect of differential fawn mortality does not appear to be working any permanent change in blackbuck reproductive patterns. During subsequent periods of high survival rates the variability inherent within the population draws fawning toward a more uniform distribution. Smaller populations show this especially clearly. In one pasture the first fawning period after a winter die-off lasted 6 weeks, the second 11 weeks and the third 14 weeks. There was a corresponding decrease in the time between fawning periods; first it was 6 months, then it was 4 months. The recruitment of maturing females into the breeding segment also increases the likelihood that fawning intervals of the individuals will overlap to the extent that no fawning peaks can be defined.

The Austrian blackbuck herd described by Schmied (1973) illustrates the synchronization that continuing winter mortality can maintain. Although blackbuck are generally cold-hardy after they reach 10 to 14 days old, fawns born to the Austrian herd in winter and early spring usually contract pneumonia and die (Schmied 1973). During 13 years, all 20 fawns lost at birth or within the first 10 to 14 days were born in the spring. Females never had young in December or January. Births were concentrated in the spring and, to a lesser extent, in September and October; fighting and general activity among the males was also most intense in spring and fall. Only three births came in the summer (one in July and two in August) and activity among the males showed a pronounced low at this season.

A possible explanation for the low number of winter births, even in the absence of severe winter conditions, is temporary summer sterility. During extremely hot weather the external cremaster muscle can no longer compensate for high ambient temperatures, testis temperature exceeds tolerable limits and the sperm die (Casady *et al.* 1953, Glover and Young 1963). It can take 7 to 8 weeks for spermatogenesis to produce new sperm (White 1968). Range animals with little or no shade available are the most prone to temperature sterility.

With feed given throughout the year and with the effects of winter extremes moderated by the shelter provided, zoo births show no more than a mild low in January and a mild increase from late spring through summer or early fall. Of 125 blackbuck born at the London Zoo (Jarvis and Morris 1961), January (seven) and March (four) had the lowest num-

ber of births. The low for 97 births at the New York Zoological Park (Crandall 1964) was one in January, and their highest months were June (13) and November (12). The San Antonio Zoological Gardens & Aquarium had lows of three births in January, April and September, and a high of 21 in August, out of a total of 91 births; that herd was not kept to a fairly constant size, however, so the yearly increments are not equivalent (Roney pers. comm.).

Sexual maturity and breeding life

The youngest blackbuck mother for whom there is an actual age on record was a female born at the Italian experiment station who first appeared in heat at 8 months and first fawned at just over 13.5 months (Taibel 1937). Some Texas females conceive when slightly younger although the general pattern seems to be for females to have their first fawns at least 6 months later than the Italian doe. Of 24 Texas females older than fawns that were checked for reproductive condition, one of two adolescents showed signs of reproductive activity (mother class X; embryo 30 mm [1.2 in] crown-rump distance) and all four subadults were near or at full term. Of the 18 adults, 8 were open and the rest, old as well as younger animals, exhibited all stages of pregnancy and lactation. Three females who were watched from birth, did not have their first fawns until they were about 22 months old. Thus, a female may reach puberty as young as 8 months but will probably not conceive for the first time until about 17 months. Similarly, females at the Austrian experiment station did not seem to reach sexual maturity until the beginning of their second year (Schmied 1973). Two Indian females in Orissa first fawned at just over 2 years 1 month and just under 2 years 5 months (Archarjzo and Misra 1973), and two 2-year olds Schaller (1967) watched in an Indian population had not yet showed signs of pregnancy.

In a number of species, but notably in blackbuck antelope, maternal care is often poorly developed in the primipare; the young tends to be feeble and soon dies (Hediger 1964, Schmied 1973). This type of immature mother may not allow her young to nurse or even to get close; such a fawn does not establish the sucking reflex, and sucking cannot be artificially induced. By the second birth, if not at the first, maternal care is normal.

With a fawning interval of 6 months, a female can have as many as two fawns a year. Some adults do fawn quite regularly almost every 6 months (Taibel 1937). Nevertheless, herd averages are lower. Schaller (1967) considered the four cases he saw of only one fawn a year are more typical in India. In the Texas Hill Country, the average is three fawns in 2 years.

A female can bear at least 15 fawns during her possible reproductive life span. An Austrian doe who first gave birth during her second year had 15 fawns before she died at 12 years 4 months, an average of 1.5 fawns a year (Schmied 1973). As discussed in Chapter 5, blackbuck rarely live to 13 years of age. Another Austrian doe who also produced a fawn during her second year had seven young before she died at 7 years 10 months, an average of 1.3 fawns a year (Schmied 1937). A third Austrian doe, who died at 5 years 10 months, averaged two fawns a year, a total of seven (Schmied 1973) — assuming first parturition at about 2.5 years.

Males retain their sexual capacity into old age. An Austrian buck who had lost his dominant status about 5 months earlier still was able to breed a doe successfully at 12 years 7.5 months, just 2 weeks before his weakening condition necessitated that he be destroyed (Schmied 1973).

Like physical maturity, first copulation comes later in males than in females. In addition, psychological castration has a strong effect among bucks and can prolong the time before an individual is behaviorally capable of reproduction. This contributes to variability in the age of attaining sexual maturity. In the Zurich Zoo, a keeper reported copulation in a 14-month buck; for at least 2 months this buck and an age-mate had been the oldest males in the enclosure (Benz 1973). With a larger paddock available, Schmied's (1973) Austrian bucks reached sexual maturity toward the end of their second year, nearly a year later than the Austrian females. The earliest complete breeding sequence noted in the larger Texas areas where territorial behavior is more fully expressed involved a bachelor not quite 18 months old. He had taken over an estrous doe when her suitor violated the territory of another buck and was forced to fight. Except in small enclosures, the control imposed by territorial bucks rarely fails in this way.

Growth and maturation

As would be expected, fawns grow rapidly. At birth Texas fawns weigh about 3 to 4 kg (7 to 9 lb) and the placenta, wet but emptied of fluids, weighs about 0.4 kg (1 lb). The average 3.22 kg (7.1 lb) for 22 birth weights reported from the Austrian experiment station is similar; the range was from 2.13 kg (4.7 lb) for a stillborn female to 4.06 kg (9 lb), and males averaged 400 gm (14 oz) heavier than females (Schmied 1973). Fawns born at the Italian experiment station weighed 4.5 kg to 5 kg (10 to 11 lb) (Tabel 1937). This seems unusually heavy. Temperatures of two fawns at birth were 38.7°C and 39.3°C (69.7°F and 70.7°F) (Schmied 1973). At birth, the upper canines ordinarily are already fully developed. All the incisiforms are exposed although not fully up yet; the cutting edge of il is still oriented nearer to the vertical. The points of some of the premolar cusps are just appearing above the gums.

Within a week the fawn is coordinated, and within 2 weeks it has begun to fill out noticeably. Table 6-2 gives representative weight ranges for different age groups in Texas. By the subadult stage weight differences are marked and height differences have also become apparent.

Bucks in India are said to reach full physical maturity at 6 years of age (Bristow 1925, Stockley 1928). Schmied (1973) considers that summer lightening of the coat is less noticeable after 5 to 6 years. There is also the feeling that bucks do not become fully black until 6 years old (Baker 1890) and that the dorsal surface of the neck becomes progressively darker from this age (Stockley *in* Simmonds *et al.* 1923). However, Texas observations indicate that the general color effect results from dominant status ordinarily being easier to maintain by bucks in good condition (see Chapter 7). Old bucks in failing health for extended periods turn tan. As for darkening of the dorsal neck, no obvious correlation was observed in Texas.

Table 6-3 summarizes the body measurements of adult blackbuck on Texas rangeland. The average male height is just within the 73.7-83.8 cm (29-33 in) range determined by Meinertzhagen (1938) for 21 males from Rajasthan, part of northwestern India where blackbuck are biggest. These Indian bucks were not selected for size (Meinertzhagen 1938); neither were most of the 13 Texas bucks. From the limited Texas sample size it is hard to be sure, but the Texas bucks may average smaller than the largest Indian subspecies, even though the Texas bloodlines may be predominantly from this population (see Chapter 1). As shown in Chapter 2, the horn average definitely is smaller.

TABLE 6-2. REPRESENTATIVE WEIGHT RANGES FOR FIELD AGE CLASSES ON THE EDWARDS PLATEAU.

FIELD AGE CLASS	WEIGHT RANGE
BROWN FAWN (AT BIRTH)	3.0-4.0 kg (7.0-9.0 lb)
BROWN FAWN (YOUNG)	4.5-5.5 kg (10.0-12.0 lb)
OLDER FAWN	6.0-9.0 kg (13.0-20.0 lb)
ADOLESCENT	13.5-18.0 kg (30.0-40.0 lb)
SUBADULT FEMALE	18.0-22.5 kg (40.0-50.0 lb)
SUBADULT MALE	23.0-34.5 kg (51.0-76.0 lb)
ADULT FEMALE	23.0-32.0 kg (51.0-70.0 lb)
ADULT MALE	35.0-43.0 kg (77.0-95.0 lb)

Nutrition may be the key to the smaller Texas size. Several authors note the relation of blackbuck with the black cotton soil areas of the Deccan, and some cite soils as well as climate in explaining the better development of blackbuck in certain parts of India (Forsyth 1871, Baker 1890, Simmonds *et al.* 1923). In Texas blackbuck inhabit mainly the Hill Country (Harmel 1975) where ranges are usually heavily grazed. Consequently, they rarely accumulate significant amounts of fat for winter reserves (see Chapter 10). Aggravating this situation is the low phosphorus content of the shallow, limestone soils which makes the calcium-phosphorus ratio much larger than is considered optimum and deprives the animals of the full benefit of the food they eat. To be utilized, phosphorus must enter in organic form, so salt blocks with inorganic phorphorus will not solve the problem. Fertilizing prime food plants with a phosphate-rich medium has been tested successfully for white-tailed deer elsewhere in Texas (Robinson pers. comm.) but has not been

tried in the Hill Country. In order to show any results, such experiments require several years plus high fencing as part of a program to prevent overstocking. Some of the heaviest, longest horned Texas blackbuck, including one exceptional 65.3 kg (144 lb) buck not included in Table 6-3, come from high-fenced enclosures where the animals are maintained on feed.

Winterkills

About once every decade for as long as there have been enough blackbuck in Texas to exhibit

TABLE 6-3. BODY MEASUREMENTS ON ADULT BLACKBUCK FROM TEXAS RANCHES (111 SPECIMENS FROM SIX RANCHES ON THE EDWARDS PLATEAU AND TWO RANCHES IN SOUTH TEXAS).

Characteristics Measured	Males (N = 75)[1]		Females (N = 36)[1]	
	Mean	Range	Mean	Range
Live weight[2] 40 males 22 females	37.5 kg (82.8 lb)	19.5- 56.7 (43.0-125.0)	26.5 kg (58.5 lb)	19.0- 33.1 (42.0- 73.0)
Field dressed weight[2] (only viscera removed) 41 males 9 females	27.6 kg (60.8 lb)	21.3- 44.7 (47.0- 98.5)	19.1 kg (42.1 lb)	17.2- 21.3 (38.0- 47.0)
Heart girth 4 males 0 females	72.3 cm (28.5 in)	68.5- 78.7 (27.0- 31.0)	—	—
Shoulder height (withers to hoof) 13 males 10 females	74.6 cm (29.4 in)	67.9- 79.3 (26.8- 31.2)	70.2 cm (21.6 in)	67.2- 71.1 (26.5- 28.0)
Foreleg length (elbow to hoof) 4 males 10 females	50.1 cm (19.8 in)	46.3- 54.6 (18.2- 21.5)	47.3 cm (18.6 in)	46.3- 48.8 (18.2- 19.2)
Hindleg length[3] (hock to hoof) 43 males 30 females	35.1 cm (13.8 in)	30.4- 40.0 (12.0- 15.8)	36.8 cm (14.5 in)	29.8- 35.5 (11.8- 14.0)
Total length (tail included) 18 males 21 females	126.0 cm (49.6 in)	119.9-132.0 (47.2- 52.0)	121.5 cm (47.9 in)	109.8-135.2 (43.2- 53.2)
Tail length 13 males 9 females	10.6 cm (4.2 in)	8.2- 12.7 (3.2- 5.0)	9.4 cm (3.7 in)	7.6- 10.8 (3.0- 4.2)
Ear length (notch to tip) 12 males 8 females	12.4 cm (4.9 in)	11.4- 13.6 (4.5- 5.4)	12.0 cm (4.7 in)	11.4- 12.7 (4.5- 5.0)
Circumference of head (throat to just before ears) 2 males 11 females	45.0 cm (17.8 in)	43.1- 47.0 (17.0-18.5)	38.4 cm (15.1 in)	36.2- 41.2 (14.2- 16.2)
Circumference of upper neck[4] (perpendicular to neck axis just behind head) 12 males 16 females	36.6 cm (14.4 in)	29.2- 45.7 (11.5- 18.0)	26.8 cm (10.6 in)	24.1- 29.2 (9.5- 11.5)
Circumference of lower neck[4] (perpendicular to neck axis at neck base) 16 males 16 females	45.2 cm (17.8 in)	38.1- 56.5 (15.0- 22.2)	36.5 cm (14.4 in)	31.1- 43.1 (12.2- 17.0)

[1]Not all characteristics could be meaningfully measured on all specimens; the relevant numbers are given under each characteristic.
[2]The means for weight tend to be low because some of the weights are from winterkills.
[3]The mean hindleg length of females being greater than that of males may well be due to sampling error. Both limits for the range of observed hindleg length are lower for females than for males, and males are generally taller.
[4]Collars for tracking or recognition require extra room; slightly less than two fingers is a useful starting point.

TABLE 6-4. DISTRIBUTION BY SEX AND AGE OF DEATHS BY PERCENT DURING 1972-73 WINTERKILL PERIOD IN ONE LARGE PASTURE WITH A LARGE BLACKBUCK POPULATION, EDWARDS PLATEAU.

	MALES				FAWNS	FEMALES				
PERIOD	Old adult	Fully adult	Sub-adult	Ado-lescent		Old adult	Fully adult	Sub-adult	Ado-lescent	TOTALS
Period 1	6	7	3	3	8	5	8	0	5	45
Indeterminate	1	3	0	0	6	0	5	0	0	15
Period 2	2	1	7	3	3	5	8	7	4	40
TOTALS	9	11	10	6	17	10	21	7	9	100

mortality patterns, there has been a winterkill which has reached devasting proportions in part of the state. In the early 1950's, the Black Buck Ranch lost all its blackbuck to a winter die-off (C. Ahrens, pers. comm.). In the 1960's and again in 1972-73, other ranches lost 30-90 percent and more of their blackbuck, depending on the severity of conditions in the particular area. The extent of the die-off, or even whether there is an appreciable number of deaths at all, can be moderated by supplemental feeding but only if the animals are already taking feed regularly (see Chapters 10 and 12). Initiating the feeding after weather conditions have already become serious has little effect. This has been demonstrated repeatedly in the Hill Country where, on the same ranch, some pastures may be fed while others are not.

Cold temperatures alone are not responsible for winter mortality. Captive blackbuck on feed are hardy at temperatures well below −18°C (0°F) with only an open, unheated shelter (Crandall 1964). Such animals show no ill effects from snow (Taibel 1937). However, where Texas blackbuck are maintaining themselves on native forage, energy reserves are not usually built up and ice or snow become great hazards. When the ground is covered for 2 or 3 days, food intake can be restricted and the percentage of the diet made up of such low-quality foods as ashe juniper (colloquially referred to as "cedar") rises. Needing more energy to keep themselves warm and to digest the course browse, but getting less energy from their diet, the animals starve on a full stomach. With two or three snows in one winter or with a snow late in the season, the blackbuck start to die. Practically none of the animals caught in poor condition and treated have recovered. By the time range blackbuck begin piling against each other in open shelters, the end is already near (C. Ahrens pers. comm., White pers. comm.). When losses are heavy, populations can take 4 to 5 years to recover.

The 1972-73 Hill Country winterkill was investigated to discover how the various segments of a population are affected by adverse winter weather. In December some areas experienced an ice storm which left the grass coated. It snowed once in January and twice in February. A 327 ha (807 ac) pasture with a large blackbuck population that experienced both the ice and all three snows was the main study area. These blackbuck depended on the native vegetation for food. Carcasses were tabulated under "period 1" if they represented deaths before the first February snow and under "period 2" if they represented deaths during or after that snow. If the time of death was unclear, they were classified as "indeterminant." The fawns were treated collectively, while the other males and females were grouped on the basis of tooth wear as "old adult," "fully adult," "subadult" and "adolescent." All adult males showed coat darkening although some were darker than others.

The results (Table 6-4) corroborate the local view that, in general, dark males die first. Both old adult males and fully adult males show this same trend. More subadult males went down during the second period than the first, and adolescent bucks died in equal numbers. More fawns probably died early than late, but their carcasses were so small they were more difficult to assign with certainty. Among the females, all classes exhibited approximately equal losses except the subadults who sustained their loses during the second period. After the die-off only seven adult females and two subadult females remained alive.

TABLE 6-5. DISTRIBUTION OF DEATHS BY PERCENT DURING THE 1972-73 WINTERKILL PERIOD IN THREE LARGE AREAS (EACH ON A DIFFERENT RANCH) ON THE EDWARDS PLATEAU. A IS THE SAME POPULATION AS FOR TABLE 6-4.

	Males		Fawns	Females	
Period	Adult	Immature		Adult and Immature	Totals
A — Native forage					
Period 1	13	9	8	18	45
Indeterminate	4	0	6	5	15
Period 2	3	10	3	24	40
Totals	20	16	17	47	100
B — Native forage					
Period 1	>15	9	4	22	
Period 2	<14	>10	4	22	
Totals	29	19	8	44	100
C — Supplemental feed					
Period 1	0	1	0*	4	5
Period 2	10	23	3	59	95
Totals	10	24	3	63	100

*Believed to have been no fawns in the population at this time.

Thus, the adult classes show the only striking differences when male and female mortality are compared. Since males, particularly territorial bucks, are sexually active all year, heavy mortality can be expected among the adult males when under additional stress. Territorial bucks incur an energy deficit on socially active days which is not totally made up on inactive days (Cary 1976b). Therefore, bucks who hold territories for long periods gradually lose condition. This drain can be expected to be felt most acutely during winter when vegetation quality is lower. Ice or snow aggrevates the situation. Meanwhile, the females, who remain in groups, spend more of their time feeding and consequently are not affected as quickly. One adult buck who survived period 1 started the winter in a bachelor association and so also had the advantage of the higher grazing rate of blackbuck in group situations. By late January he was without male company but was still staying apart from the females, so there was not enough sexual activity to produce a significant rise in energy expenditure. He probably would have survived the winter if there had not been snow in Feburary.

Increased mortality among subadult males during period 2 may reflect a release from the dominating effect of adult bucks who prevent younger bucks from courting females (see Chapter 3). With the drastic decrease of adult males, the subadults probably broke up their bachelor groups and became sexually active, thus incurring the same problem of an energy deficit that was thinning the ranks of their elders. Even if vigorous fights between rival subadult suitors are infrequent, the driving of females by subadult males involves more chasing than is indulged in by adult bucks. This increased chasing, the stress of carrying a fetus while not yet fully mature or a combination of these may explain the concentration of subadult female mortality in the second period. The high incidence of females found dead with a fawn only partially delivered (Fuchs pers. comm.) or dead beside a neonate fawn indicates that the pregnant females entered spring in a weakened condition.

Adolescent females and males both died in equal proportions in the two periods. The few adolescent females who had conceived were still in the early stages and under little stress of pregnancy. The adolescent males, like the adolescent females, still enjoyed the continuous security of the female groups because these males had not yet been driven out by the territorial bucks (see Chapter 3).

Table 6-5 compares this pasture (A) with two other Hill Country pastures (B and C). Ex-

cept that fewer age groups were distinguished, the nearby pasture B showed similar mortality trends. The actual percentages for the males in the two different periods were not released for pasture B, but total percentages and information about which period was greater were available. Pasture C was farther west and missed the December ice storm. The weather generally was milder until the end of the winter. This is reflected in the low loss rate for period 1. Period 2 losses were high, but not as large a percentage of the total population was lost during the entire winter as in the pastures A and B.

Population structure

The Texas blackbuck show an unstable population structure. The fluctuations (Fig. 6-4) can be explained in terms of the periodic winterkills. As shown by comparing the age pyramid for a large population subsisting on native forage (97 animals found dead) with the rest of the Texas sample (N = 407), the same mortality pattern shows in both but the effects are less extreme for all the blackbuck considered together. Two die-offs are recorded for the single pasture, one in the late 1960's and another during the winter of 1972-73 when the principal data for this age distribution was gathered. The latter winter was particularly severe, killing over 90 percent of the population in that pasture.

Two features are of special interest. The population takes 4-5 years to recover numerically after a winterkill. Furthermore, it is probably significant that where the effects of winter extremes were not moderated artificially there were no animals in the oldest age class. The total Texas sample did not have many old animals either, but the number for their age classes decreased more slowly and the oldest appeared to survive longer.

The survivorship curves for the Texas blackbuck generally (Fig. 6-5A) and for the example population (Fig. 6-5B) also show the virtually constant mortality rate among the old adults. Mortality among juveniles under 1 year is high but improves markedly as adulthood is reached. The bulk of the population falls within the section of the curve showing a negative skew rectangular pattern like that of Dall's sheep whose survivorship Deevey (1947) discusses. Adult blackbuck survival tends to be good until the animals approach 5 years of age and then it falls rapidly until age 7 to 8 years after which it levels off again. This sharp decline comes just when the blackbuck should be in their prime. The drop is not caused by hunting, for it characterizes the unhunted, single population as well as the total sample (Fig. 6-5). This supports the suggestion that better survival is one reason for longer horn averages in India (see Chapters 2 and 5). Average length of life is only about 4 years in Texas (3.79 for the combined sample, 3.84 excluding the single pasture

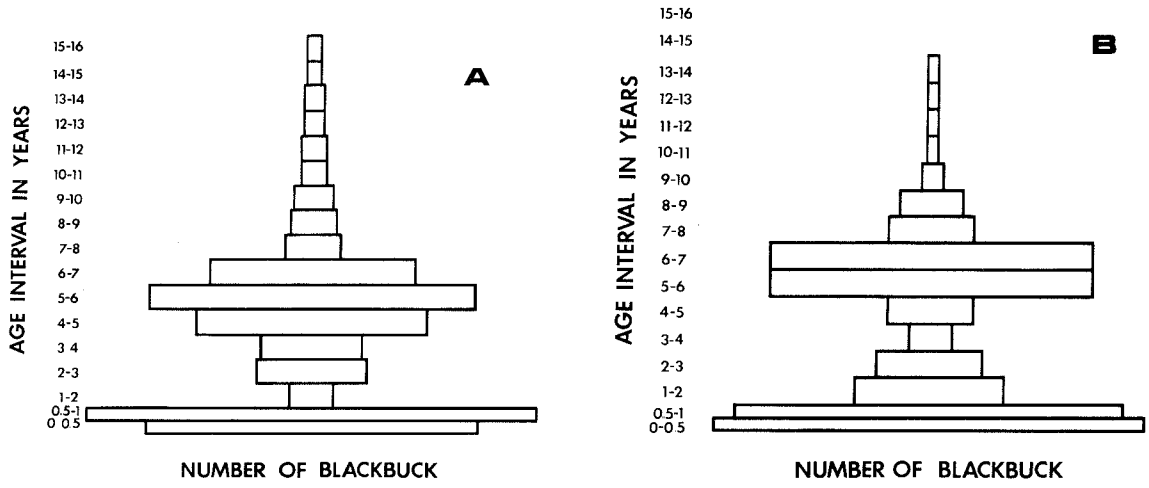


FIG. 6-4. Texas age pyramids for combined sample of 407 blackbuck (A) and one population of 96 blackbuck not included in combined sample (B).

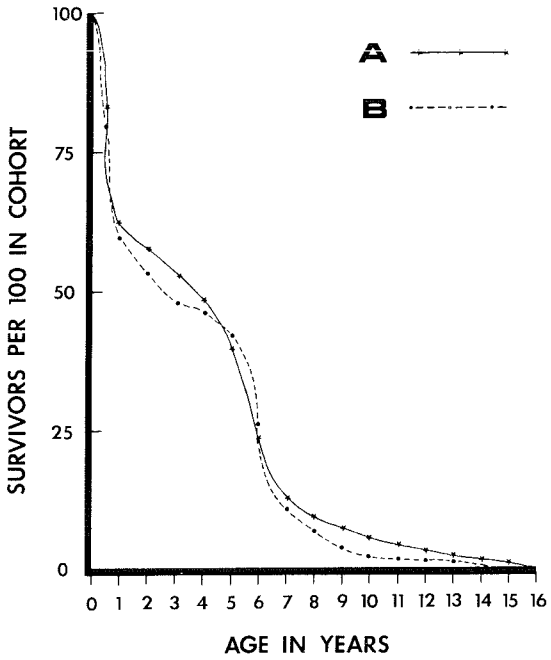


FIG. 6-5. Texas survivorship curves for all 503 blackbuck assigned ages (A) and for one population of 96 blackbuck included among the total sample of 503 (B).

and 3.50 for the single pasture in which the maximum longevity was lower). Although Schmied (1973) gives the average age at death for 19 Austrian blackbuck as 4 for males and 3 for females, he points out that these estimates do not take into account the animals still living. This proviso would be less important were it not that the Austrian herd was started using only fairly young blackbuck (about 12 to 18 months).

Adjusted to cohorts of 1,000 in order to simplify comparison with each other or with life tables for other species, Table 6-6 gives life tables for the combined sample and for the single population. For each age (year class x) it gives the age as percent deviation from the mean length of life (x'), number dying during the age interval (dx), number surviving at the start of the interval (lx), mortality rate per thousand alive at beginning of the age interval (1,000 qx) and mean lifetime remaining to the individuals who reach the age interval (ex). The first value in the ex column is average length of life, since at birth all individuals in the cohort can be expected to have an average life span. In the x' column the change from negative to positive indicates the age interval (smaller absolute value) containing the average length of life. As forecast by the similarity of the age distributions and of the survivorship curves, the life table for the single population closely approximates that for the total sample.

Sex ratios

The sex ratio at birth is essentially 1:1. Over a 13-year period the ratio for 61 births at the Austrian experiment station averaged 1:1.3 males to females in spite of two years when the aging master (11 and 12 years old) of the herd begat predominantly male offspring (Schmied 1973). Eleven births (combined total for two females) at the Italian experiment station averaged 1:1.2 (Taibel 1937). Sexing of fawns is often difficult, but for the total Texas sample immatures estimated by tooth criteria to be 6 months to 1 year old occurred in a 1:1.0 ratio. In the single, unhunted population, however, the ratio for the comparable age group was 1:1.5; this carried through as the ratio of males to females for the population 1 year old and over.

In the total Texas sample, which includes hunted populations as well as unhunted ones, the male to female ratio was 1:0.9, still nearly 1:1. As illustrated in Fig. 6-6, mortality seemed to exert a heavier effect on the younger males, but in the oldest age classes eliminated the females before the males. The sudden decrease in mortality rate at 7 years of age already discussed applies to both sexes.

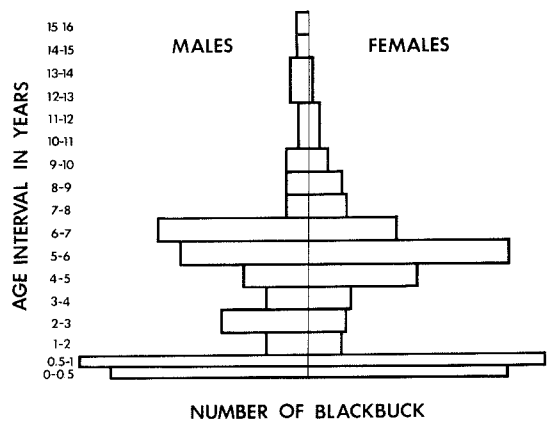


FIG. 6-6. Texas age and sex pyramid for 466 blackbuck. All animals estimated to be 1 year or older are of known sex, but animals less than 1 year are apportioned assuming a 1:1 sex ratio.

TABLE 6-6. LIFE TABLES FOR BLACKBUCK ANTELOPE IN TEXAS BASED ON AGE AT DEATH: (A) ALL 503 SAMPLES FOR WHICH AGE WAS ESTIMATED, (B) ONE POPULATION OF 96 ANIMALS FROM ONE PASTURE REPRESENTING THE WINTERKILL PERIOD IN 1972-73 (SAME AS FOR TABLES 6-4B AND 6-5B).

x AGE (YEARS)	x' AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	d_x NUMBER DYING IN AGE INTERVAL OUT OF 1,000 BORN	1_x NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1,000 BORN	$1{,}000q_x$ MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	e_x MEAN LIFE-TIME REMAINING TO THOSE ATTAINING AGE INTERVAL (YEARS)
A					
0 -0.5	−100.00	171	1,000	171	3.79
0.5- 1		215	829	259	
1 - 2	− 73.61	32	614	52	4.86
2 - 3	− 47.22	53	582	91	4.10
3 - 4	− 20.82	44	529	83	3.46
4 - 5	+ 5.57	91	485	188	2.72
5 - 6	+ 31.96	159	394	404	2.24
6 - 7	+ 41.79	111	235	472	2.41
7 - 8	+ 84.74	30	124	242	3.13
8 - 9	+111.14	24	94	255	2.97
9 - 10	+137.53	18	70	257	2.81
10 - 11	+163.92	11	52	212	2.62
11 - 12	+190.31	11	41	268	2.18
12 - 13	+216.71	9	30	300	1.80
13 - 14	+243.10	9	21	428	1.36
14 - 15	+269.49	6	12	500	1.00
15 - 16	+295.88	6	6	1,000	0.50
B					
0 -0.5	−100.00	208	1,000	208	3.50
0.5- 1		188	792	237	
1 - 2	− 71.39	73	604	121	4.46
2 - 3	− 42.78	52	531	98	4.00
3 - 4	− 14.16	21	479	44	3.38
4 - 5	+ 14.45	42	458	92	2.52
5 - 6	+ 43.06	156	416	375	1.72
6 - 7	+ 71.67	156	260	600	1.45
7 - 8	+100.29	42	104	404	1.88
8 - 9	+128.90	31	62	500	1.81
9 - 10	+157.51	11	31	355	2.11
10 - 11	+186.12	5	20	250	2.00
11 - 12	+214.74	5	15	333	1.50
12 - 13	+243.35	5	10	500	1.00
13 - 14	+271.96	5	5	1,000	0.50

In India all populations investigated have shown fewer males than females. The large population of 750 to 800 blackbuck at Point Calimere had a 1:1.4 ratio among the immatures older than fawns; this decreased to 1:1.8 for the adults (Daniel 1967). Daniel (1967) suggests poaching as a possible cause for this decrease among the males.

A tally of carcasses when 30 to 40 percent of India's largest blackbuck population perished during a cyclone with heavy rains revealed a 1:2.3 sex ratio among 727 animals after the 196 "young" had been subtracted from the totals (Acharya and Rashid *in litt.*). For yearlings and above in three other populations, Schaller (1967) found the highest ratio (1:1.8) among Keoladeo Ghana Sanctuary's more than 82 blackbuck, a similar ratio (1:1.7) among the approximately 70 animals at Chilka Lake and the lowest ratio (1:1.2) among a herd of 126 at Sikandra. Unlike the other populations, the Sikandra blackbuck are closely confined; their movements are limited to a 20.2 ha (50 ac) enclosure (Spillett 1966, Schaller 1967). In the three latter populations plus a small one in Kanha National Park, the disproportion of females was always already evident in the yearling class (Schaller 1967).

Summary

The reproductive characteristics of blackbuck, their development and their mortality patterns combine to produce the dynamics of their populations.

Because of an X-autosome translocation, fertilization yields XX females (2N = 30) but XY1Y2 males (2N = 31 or sometimes 33). Reproductive anatomy resembles that of domestic sheep and cattle. Observations suggest that it may be typical for the fetus to develop in the right, rather than the left, uterine horn. Although the mother's milk may vary in fat content, the other solids remain fairly constant. Since cow's milk differs widely from blackbuck milk, it should be modified if it is to be used to feed an orphan blackbuck.

The blackbuck female is sexually receptive to the male for about 24 hours during each estrous cycle. Regardless of season, each cycle takes 5 to 6 days with the female continuing to recycle until bred. In Texas the first heat after parturition probably comes at about 2 weeks but the doe does not seem to be bred until 4 weeks. Reports from Austria indicate that the timing for the first estrous cycles after parturition tends to be irregular and that lactation may have some inhibitory influence. Characteristically, the doe is soon rebred and lactation and development of the new embryo go on simultaneously. Although the average fawning interval is 6 months, gestation seems to be only 5. Blackbuck do not twin.

This tropical species does not have a seasonal rut in the sense that temperature-zone ungulates characteristically have. Instead, there tend to be seasonal highs and lows in general activity. Peaks in true "rutting" activity, as distinct from routine displaying, result from peaks in the number of estrous females present. The blackbuck males are reproductively active all year and so can breed a female at any season. Fawning peaks result from changes in environmental conditions such as winterkills or excessive summer heat. In the absence of extremes, fawns are born throughout the year.

A female may reach puberty as young as 8 months but will probably not conceive for the first time until about 17 months. Maternal care is sometimes inadequate in the primipare but is normal therafter. Although some females fawn regularly every 6 months, the average is about 1.5 fawns a year. During her reproductive life span, which can extend at least into the 12th year, one female can bear up to 15 fawns; usually there are no more, since blackbuck rarely live to 13 years of age. Males also retain their sexual capacity into old age. Like physical maturity, first copulation comes later in the male than in the female — anywhere from early to late in the second year, depending on the social situation.

At birth, males already average heavier than females. Fawns grow rapidly. Bucks are said to reach physical maturity at 6 years. Horn length and possibly body size of adult bucks is small compared to the largest subspecies in India. The phosphorus-deficient soils typical of the Hill Country are postulated as a cause.

About once every decade, Texas blackbuck experience a winter die-off. The extent of a die-off can be reduced by supplemental feeding, but only if the animals are already taking feed regularly.

Texas blackbuck show an unstable population structure. For animals younger than 1 year of age the usual mortality rate is high. Then it levels off until 5 years of age when it increases rapidly again. Thus blackbuck are ending their lives just as they should be entering their prime. Average age in Texas is only 4 years. At 7 to 8 years, mortality stabilizes again. These fluctuations can be explained in terms of the periodic winterkills. The population takes 4 to 5 years to recover numerically after a die-off.

The sex ratio at birth is essentially 1:1. The total Texas sample showed a 1:1 ratio for all classes together, but one population analyzed singly had a 1:1.5 ratio of males to females. In India females always predominate; ratios for large populations range from 1:1.2 to 1:2.3. This disproportion is already apparent among the yearlings and may increase among the adults.

7

COLOR/COLOR CHANGE

☐ What makes the blackbuck such a striking creature? Even more than the diverging horns, ringed and spiralling, it is the male's sharp contrast of white against black (see front and back covers). The females and immature males, too, have white eye rings, chin patch, underparts and inner legs, but the pattern is not as eye catching against their tan ground color. However, not all adult males attain the dark coat; some remain as tan as the females and immatures (Percy 1894, Lydekker 1907, Stockley 1928) and change to a dark ground color is not necessarily permanent. Clearly, sex and age are not the only variables involved in the color change of the Indian blackbuck antelope. Season of the year and social status also interact with the individual's genotype to affect coat color.

Sex and color development

Only normal male blackbuck turn black. However, both males and females as they reach maturity grow some dark hair. The hair starts to darken over the nasal bones, and often the pigmented areas of the forelegs and lower hind legs turn dark as well. The border of colored hair meeting white near the point of the shoulder is also likely to darken, as is the stifle area. The faces of males turn black on the ridges above the eyes and on the nose. These changes are permanent.

The male's change to a dark ground color is gradual. First the hair on his ventral neck and lower shoulder darkens. Then the darkening extends up the sides of the neck, over the head, onto the shoulders and along the side streak (Fig. 7-1). At the same time, the dark area at the stifle expands. Next, the lower sides and lower haunches start to change. The side streak turns a light pepper near the start of the change and stays this way until the rest of the coat is

uniformly a darker pepper. Then the side streak turns black and remains visible unless the sides turn very dark. Only at the last does the back darken. Even the blackest bucks retain a rich chestnust or russet color over the loins and croup, or at least immediately anterior to the tail, and onto the tail itself. Near the white rump area, the haunches often stay tan or gray. In many bucks, the gaskins or the legs below the hocks never change. Bucks who go from tan to brown or almost black on the dorsal neck are uncommon. Most bucks at their darkest are likely to be dark brown rather than black. Many bucks gain no more than a pepper color the first season that they change.

A transient color change results from the blackbuck's habit of erecting the hair along the neck and body when excited or uncomfortable. This is because the tips of the hairs are dark in virtually all individuals, whether they are fawns, females, immature males or adult bucks. When the hair rises, the ratio of length of visible dark tip to length of visible light shaft increases so the coat color appears deeper. Very few females have dark tips long enough to make a detectable change, but dark males have the dark pigment extending far down the hair shaft. By no means do all males have the whole shaft become dark so only the reduction of glare when the hair is erected can make them appear any darker than when they are relaxed.

The sole report of a black doe comes from India, but this abnormal animal was horned and may have been hermaphroditic. G. (1909) shot what he thought was a black male with freak horns. On reaching the carcass, he was surprised to find that his prize appeared to be a horned female (G. 1909). Each of the other "horned females" on record from either India or Texas, whether a true female or a hermaphrodite, has been tan. (For further discussion of "horned females," see Chapter 10.)

Age and season

In addition to the obvious variable, sex, there are two major aspects to the color change. One is the general darkening which occurs only after maturity. This is not contested. Even when a buck is the only male with a group of adult females, he is 12 to 15 months old before he can show as much as a lightly peppered head and ventral neck. Some bucks do not darken for at least 2 years after maturity. A few never darken at all, except for the brown or black on face and lower legs that is characteristic among all adults. Most bucks, however, darken either during their first fall as mature animals, at 2 to 2.5 years of age, or during the next fall season.

The other major aspect is the seasonal cycle of lightening early in the year and then darkening again at the molt toward the end of the year. There is considerable confusion over this seasonal component because some males lighten more than others and some show no lightening at all (Baker 1890, Lydekker 1907, Brander 1923, Simmonds *et al.* 1923, Stockley 1928, Dharmakumarsinhji 1959, Crandall 1964, Prater 1971).

Pocock (1910) verified the regularity of the seasonal change for a buck in the London Zoo by making observations on an individually known male for 3 consecutive years. In late August, this male gradually turned black. Toward the beginning of May, it turned tan again. The pattern for seven individually known bucks watched in the Texas Hill Country has been similar. During the winter they were dark, and during the summer they were lighter. Schaller (1967) describes a similar case for a buck in its native India. His animal turned brown by late March, early in the hot season, and then turned black again during the latter part of the subsequent wet season, becoming fully black in August. Allowing for phenologic shifts with locality, this pattern probably represents the norm in India. The ancient Shastras note that, ". . . the sun of the month of Kunwar (Ashwin) 'Vishwamitri Unhala,' which is concurrent with the month of September and October, is so hot that its rays blacken the backs of the black buck." (H. H. The Maharaja of Dhar *in* Simmonds *et al.* 1923, p. 835).

Close observations of Texas bucks show that by January the new coat, which may not be completely revealed until May or June, is already growing. This gives the blackbuck an extra layer of 0.5 cm (0.25 in) hairs beneath their 2.5-3.0 cm (1-1.25 in) winter coat during the coldest part of the winter. By August, enough of the short summer coat has been replaced for the buck's winter coat to be indicated. Some individuals start changing earlier than others and, thus, lighten again sooner, but during the

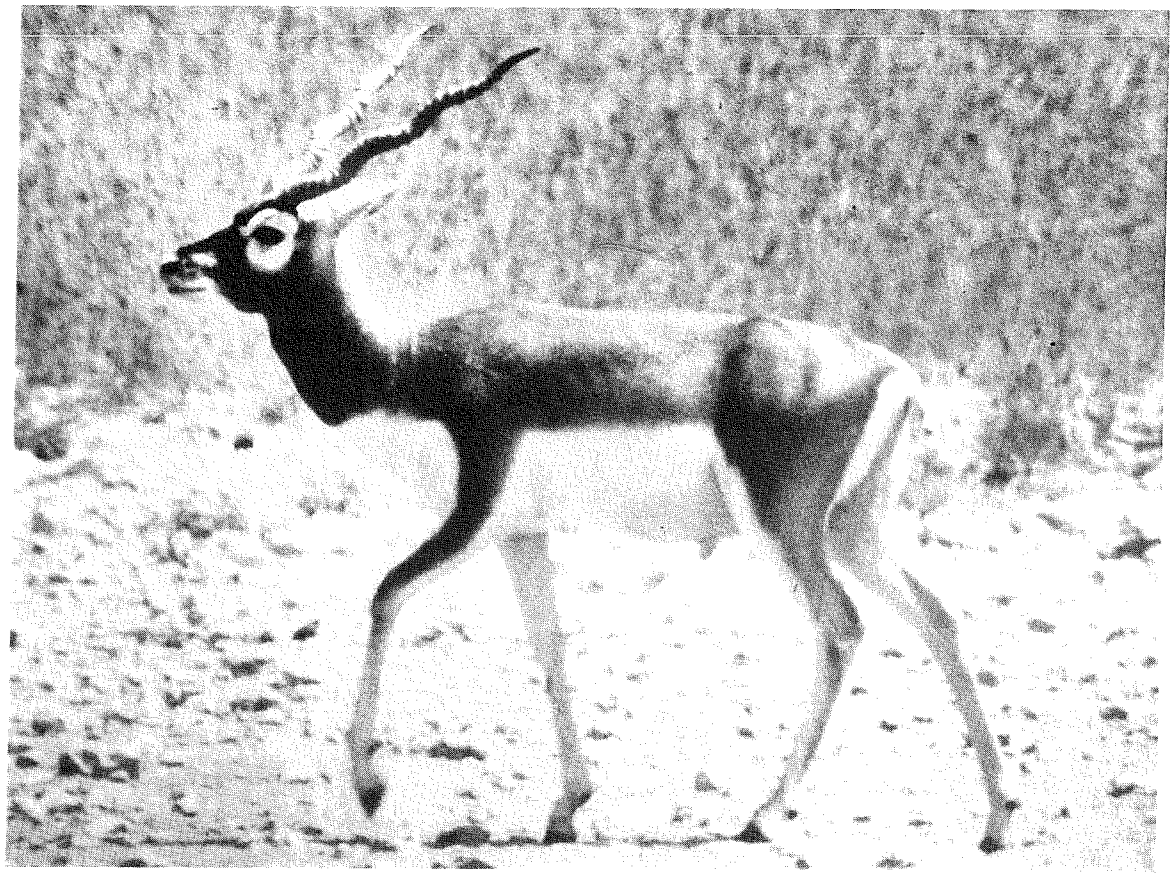


FIG. 7-1. Adult buck showing incomplete coat darkening.

beginning of December the first bucks to turn are still at their darkest and the last bucks to turn have reached their maximum depth of color.

Apparently, bucks in the northern part of their native distributional area generally turn blacker at their darkest and do not lighten as much during the hot season as do bucks in central and southern India; in the latter areas, bucks are more often dark brown at their darkest and tan at their lightest (Andrews *in* Simmonds *et al.* 1923, Stockley *in* Simmonds *et al.* 1923, Stockley 1928, Prater 1971). Moreover, it is said that mature bucks who never turn dark are more common in central and southern India than to the north (Lydekker 1907, Stockley 1928). In all areas the darkest winter coats approach black. The darkest summer coats are only dark brown to which the fading action of the sun adds a rusty tinge.

This tendency for a generally lighter coat in the more southern reaches of blackbuck distribution, in particular the more marked change during the hot season, may correlate with differences in the need for protection against the effects of incident radiation. With rising temperatures, other large ungulates seek shade before blackbuck. This is true both in India (Schaller 1967) and in Texas. The darkly pigmented skin of the blackbuck protects against the sun. The skin is blackest along the back shading to a lighter gray underneath. The tip of the tongue is black as well. Although the short hair that forms the eye rings is white and although most of the vibrissae growing there are white, the eyelashes are dark like the skin. To a variable extent, some individuals show small patches of pink skin but only on the inner lips or on the area usually covered by the tail.

Even at their darkest, bucks are usually tan (or brown) on the dorsal surface of the neck (Fig. 7-2; see also front cover); they darken last and lighten first on the back and haunches. Even tan blackbuck are often lighter on the dorsal neck. Of 50 such animals examined closely, more than 18 percent had no dark-

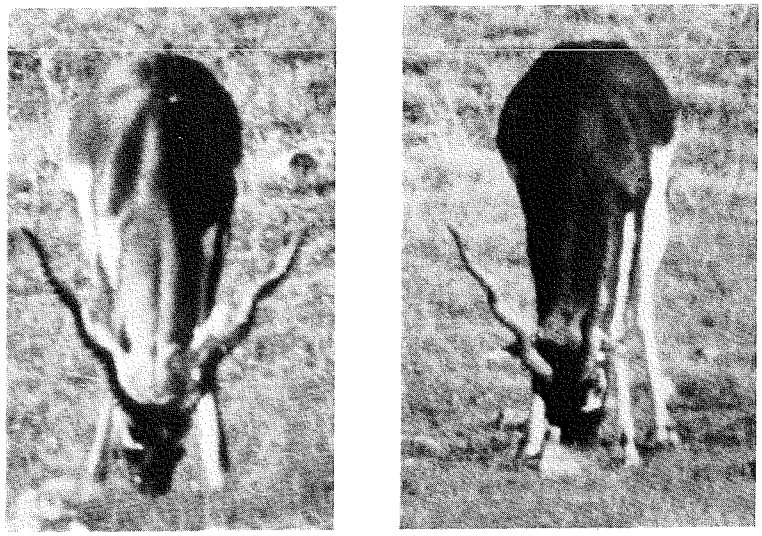


FIG. 7-2. Black males with typical tan dorsal neck (left) and with the much less common black dorsal neck (right).

tipped hairs on the dorsal neck or fewer there than on the rest of the body. Considering sheep and camels, MacFarlane (1964) showed that it is the dorsal surface of an animal which heats most in the sun; insulation effects of the hair coat act to minimize both the general increase and the internal differential between dorsal and ventral temperature.

In short-coated camels the hair also protects by reflecting solar energy, and sweating helps cool the skin; gazelles are similar (MacFarlane 1964). The concentration of pigment on the outer surface of the hairs, leaving the undersides lighter, also points to the importance of the hair coat in protecting the animal from excessive radiation. Lighter surfaces reflect more than dark ones, shielding the animal more effectively. In addition, the dark color which accentuates the white patches conspicuous in the sexual and aggressive displaying of the male and increases sexual dimorphism may have to be lightened during the hot season in order to protect the animal. The result is a seasonal color change correlating primarily with environmental factors rather than reproductive function. Schaller (1967) noted that his Indian buck, described earlier, was black during the major seasonal aggressive and sexual peak, but brown during the minor peak. Possible peaks of rutting activity not withstanding (for further discussion of reported peaks, see Chapter 6), blackbuck males are sexually active all year (Taibel 1937, Hediger 1949, Etkin 1954, Backhaus 1958).

Social status and testosterone

In spite of the fact that blackbuck in Texas probably trace their ancestry to several Indian areas rather than just to one, differences in social status seem more significant than genetic variation in relation to coat color. Records of known individuals on the Edwards Plateau show that the male in one pasture who stayed darkest (brown) during the summer was also the male who maintained the highest degree of territoriality during the summer. In a closeby pasture, a buck who was able to keep the one female group almost exclusively within his territory for more than a year went only from black to brown during the summer. Meanwhile, two other mature males in the latter pasture were rigorously kept away from the females and spent most of their time with the immature males. These two bachelor males went from black in winter to tan in summer. The second fall only the dominant of these two bachelors turned black. The "inferior companion," whose health had deteriorated and who was being forced to give way more often before his "superior companion" (Mungall 1977), failed to gain more than a richer tan and a few dark hairs at the shoulder. The fate of an Austrian buck further illustrates that color differences follow status changes. After a dark adult lost his dominant role, he turned tan and remained tan for the rest of his life (about 2 more years) (Schmied 1973). Moreover, none of the other males in this paddock, even adults, ever became

as dark as the highest ranking buck (Schmied 1973).

Among free-ranging white-tailed deer, the older, heavier bucks are of higher social rank and take breeding precedence over the younger, smaller males (Brothers and Ray 1975). Sampling from a wild population, Mirarchi *et al.* (1977) noted that the older whitetail bucks also average higher androgen levels. Similarly, a direct correlation between social rank and testosterone levels has been demonstrated in male rhesus monkeys (Gwynne 1973). Indications are that subordinate status results in suppression of testosterone production in blackbuck as well. Certainly behavioral suppression is evident.

Observation of penned bachelors suggests that if the dominance relationship changes drastically between two bachelors, there is also a change in body condition and in coat color. The three lowest ranking of a group of six bucks penned together were given a series of injections for 2 months both winter and summer. The omega buck and his immediate superior received testosterone and the other buck received human chorionic gonadotropin (HCG) to attempt to duplicate the effect of normally produced luteinizing hormone (LH) in stimulating testosterone production. At the start of the experiment, the alpha buck had a pepper coat as did the beta buck (Fig. 7-3A). The gamma

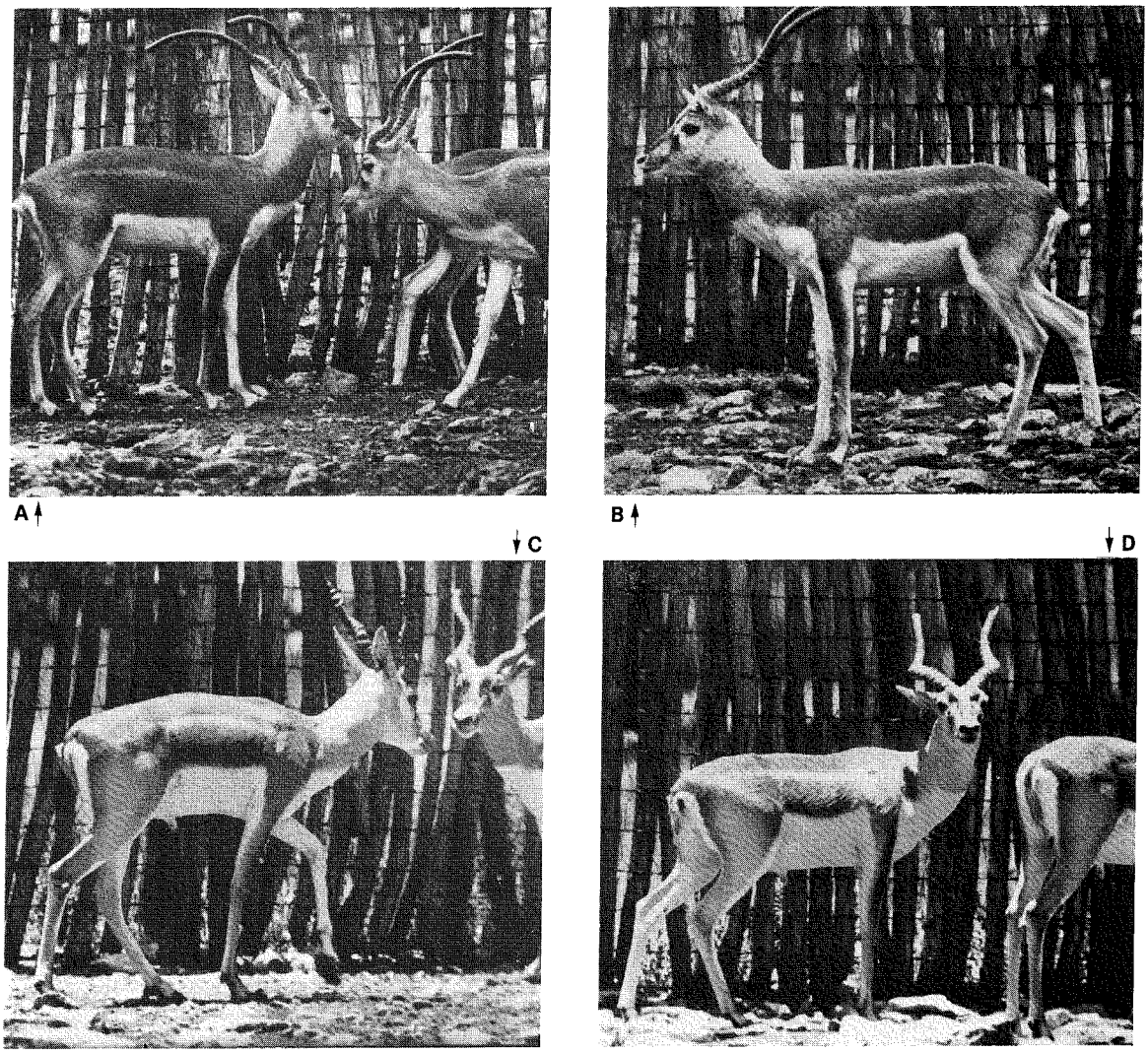


FIG. 7-3. Coat color comparisons of alpha and omega bachelors during hormone experiment: (A) The first winter the alpha buck (broadside in center) had a pepper colored coat. (B) The first winter the future alpha buck showed little darkening. (C) By summer the former alpha buck had turned tan. (D) By summer the new alpha buck was also tan.

buck showed some dark color (Fig. 7-3B). Two others showed very little and one buck showed none. This was the first time any of these bucks had been dark at all. All of the bucks lightened during the summer (Fig. 7-3C and D).

By the next fall the former alpha buck, now only slightly darker than the gamma buck had been the year before, had sunk to fourth in rank, the position the new alpha buck had held at the start of the experiment. The new alpha buck, who had been injected with HCG, showed little dark hair pigment the first winter but gained maximum black color the second winter. At the end of the summer injection series, the buck who initially had been the alpha animal showed only 0.59 ng/ml testosterone in the blood, the lowest reading of the experiment for any buck. This was comparable to the 0.66 ng/ml shown by the omega buck at the same time. The corresponding radioimmunoassay for the buck that had already taken over the alpha spot by then was 3.95 ng/ml, the highest reading for any buck at any of the four sampling periods.

Testosterone increases after termination of strict behavioral suppression may well be what finally causes the assumption of dark color in bucks who fail to change on reaching maturity. A fat buck in a small enclosure with no blackbuck females but with deer of both sexes failed to darken except on the head until the other blackbuck males were withdrawn. This released him from any dominating restraint from members of his own species. At least 2 years after physical maturity and more than a year after the removal of the last dark antelope buck (C. Ahrens pers. comm.), the remaining buck finally began to change color.

The buck just described had had no female companionship since adolescence. Perhaps if he had, he would have darkened faster. In Texas (Land pers. comm.) it has long been the impression that when a dark buck who has been with a group of females is suddenly removed, as by hunting, that another buck will shortly turn dark. Sometimes it will be a much younger buck if no older adults are present (Land pers. comm.).

Findings on domestic bulls may explain both this phenomenon and the summer color differences among bucks. Teasing, of the type involving mounting without intromission, or even just the sight of a cow stimulates circulating levels of LH in the bull to climb to more than 17 times their normal level; increased LH causes increased testosterone production which peaks about 30 minutes later (Katongole *et al.* 1971). Once released from the inhibitory influence of a more dominant buck, a blackbuck with a comparable mechanism and access to antelope females would experience higher testosterone levels more frequently and, therefore, turn darker. Bucks without females may take longer to develop sufficient levels to give a dark coat.

During the spring the general level of aggressive activity is high among bucks (see Chapter 4). If this is associated with elevated circulating testosterone concentrations, then testosterone may be high enough for most healthy adults to be dark by the next fall. During the winter the corresponding activity levels are low, so, according to this hypothesis, the only bucks that stay dark are those with increased testosterone levels stimulated by continual, uninhibited encounters with females.

Color as a secondary sexual characteristic

Dark coat color is one of the secondary sexual characteristics of blackbuck males. Testosterone, or a closely related substance, is generally regarded as responsible for development and maintenance of secondary sexual characteristics in all vertebrates (Lee and Knowles 1965). Certainly among cattle, like blackbuck in the family Bovidae, testosterone has this function. Considering that Sorensen (pers. comm.) found, when studying the effects of androgenic and estrogenic hormones on the Hereford bull, that administering testosterone resulted in a darkening of coat color, it is postulated here that testosterone is linked to the color change in blackbuck.

Color of castrates

Deprived of testicular testosterone, blackbuck males remain tan all their lives. A London Zoo buck who had been castrated — it is believed, in adolescence — was still tan when described at maturity (Bennett 1836). A mature castrate of

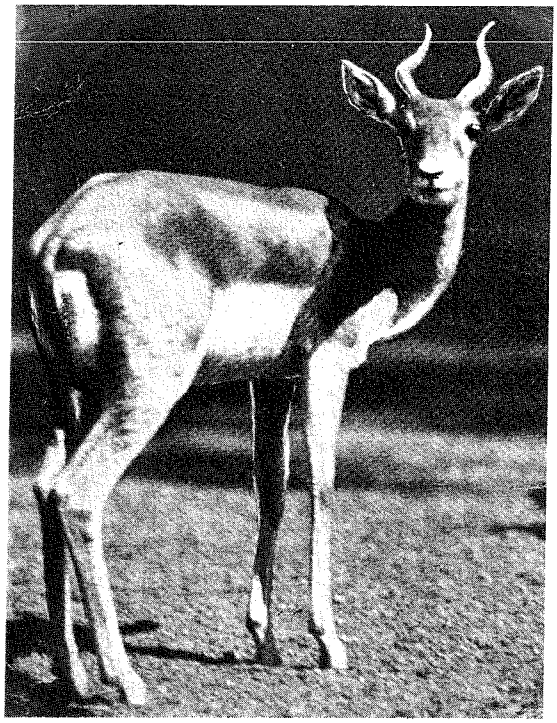


FIG. 7-4. Hagenbeck's photograph of a mature, castrated blackbuck. (Photograph courtesy I. Krumbiegel from Krumbiegel 1955.)

whom Hagenbeck had a photograph (Krumbiegel 1955) was tan (Fig. 7-4). Even its face showed no darkening, although bucks, whether dark or tan, typically have dark faces after maturity.

Vasectomy, however, appears to have no direct effect on color change. Although this operation prevents sperm from being ejaculated, it does not interfere with testosterone secretion or with sexual activity. After a vasectomy that terminated his successful breeding career, a Texas buck maintained both dark color and dominant status through all seasons (Benavidez *in litt.*, Jones pers. comm.).

Other precedents for a link between coat darkening and testosterone in bovids involve nyala, sitatunga and nilgai. Although males of these species do not seem to show seasonal color variation, they, too, typically exhibit marked sexual dimorphism in coat hue; the maturing males become dark brown, dark gray or black while the females stay light like the youngsters. At least in the nilgai males depth of color even seems to correlate with social status (Brown pers. comm.) the way it does in blackbuck. In one case a charcoal-colored nyala castrated as an adult reverted to the chestnut shade characteristic of females and immature males (Doherty pers. comm.). Similarly, a sitatunga castrated as a 14-year-old changed to female coloration at the next molt (Van den bergh *in litt.*). (For sitatunga and blackbuck, see also section on chromosomes in Chapter 6.) Like castrated blackbuck, castrated nilgai fail to develop the usual secondary sexual characteristics. These nilgai are tan, they do not grow a thick neck, they never have a large bell and their horns are somewhat underdeveloped; in short, they look like the animal examined by Roberts and determined to be a horned female (Brown pers. comm.). One individually known nilgai castrated after achieving some gray hairs ventrally on the body was released and continued to look the same when sighted periodically over a period of approximately 3 years (Brown pers. comm.).

Testosterone action

There are numerous case studies in which animal colors or seasonal color changes are affected by hormones. Working with yellow agouti mice, Geschwind *et al.* (1972) found that, given the proper genetic environment, administration of melanocyte-stimulating hormone (MSH) at the time of hair growth resulted in regeneration of black rather than yellow hair. Seasonal variation in the color of mature males can also be under hormonal control; such seasonal changes correlating with hormonal changes are well known in certain bird species (Turner 1955).

In the male, testosterone is produced in the interstitial cells of Leydig in the testes. Production is stimulated by interstitial cell stimulating hormone (ICSH) which is the same as LH that is involved in maturation of the ovarian follicle and ovulation when produced by the female. Zarrow (1968) assumes that LH release is stimulated by environmental cues such as light or temperature in seasonal breeders. During the mating season, sheep, goats and deer show increased gonadotropin secretion resulting from nervous stimulation caused by changes in photoperiod or climatic factors (Guyton 1971). Lincoln and Guinness (1972) demonstrated that putting roe deer on a light regime altered to bring them through the equivalent of the winter

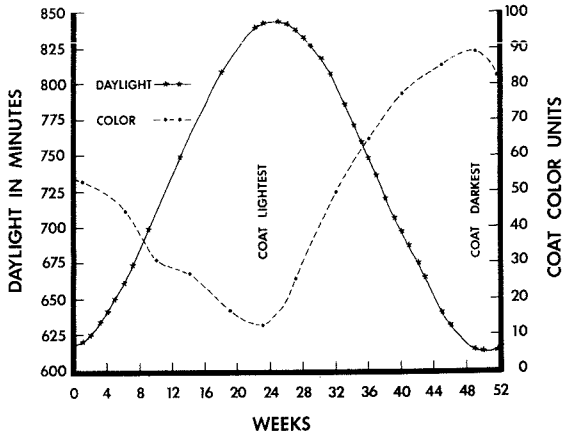


FIG. 7-5. Annual cycle of daylight length compared with coat color variation averaged for a group of six bachelors.

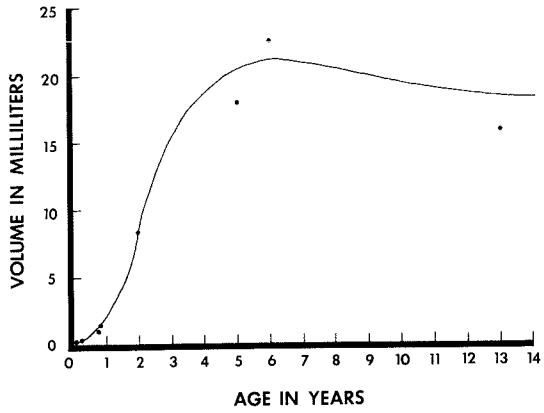


FIG. 7-6. Testis growth curve (volumes for left and right averaged; epididymis included; N = 12 blackbuck).

solstice two months early resulted in their starting to shed their winter coats two months early.

Fig. 7-5 displays the day-length cycle experienced by blackbuck, both in Texas and in the northern part of their native range, in relation to the times of year when the animals average darkest and lightest. A mechanism timed by photoperiod, regulated by LH production and operating through the effects of testosterone levels could be the basis for the color change in blackbuck. The chemical and physical properties of LH vary from species to species. LH has a molecular weight of 30,000 as extracted from sheep pituitaries and 100,000 from swine pituitaries (Zarrow 1968). Thus it is reasonable that the circumstances of its release and the details of its action may vary from species to species.

Testosterone is the obvious darkening agent because of its association with the physiological and behavioral phenomena that correlate with color. Examining the internal processes involved, it is first noted that blackbuck hairs have an agouti pattern: dark at the tip with a subterminal light band and sometimes a dark band below this. In rodent and lagomorph agouti hairs, the bulbs produce both eumelanin (black, dark brown or, with genetic dilution factors, cream) and phaeomelanin (light brown or yellow), and the hairs may be banded according to genetically determined patterns (Fox and Vevers 1960). The composition of melanin (black, brown or reddish-brown) is not fully known, and it probably varies in different species (Fox and Vevers 1960). Melanin granules in vertebrates may be made up of protein linked with melanin (Fox and Vevers 1960). Therefore, the general protein anabolic action of testosterone which results in increased quantities of melanin (Guyton 1971) probably causes the darkening of the blackbuck male, lower testosterone concentrations supporting only lower levels of pigment granule production.

Melanin granules are formed within melanocytes which derive from melanoblasts that have migrated from the embryonic neural crest to the dermis (Fox and Vevers 1960). After migration of melanocytes from the dermal papilla into the epidermal bulb, melanin granules move into cells of the hair cortex and, thus, are incorporated into the keratinizing cytoplasm (Fox and Vevers 1960). The pigment granules color the hair, and the hair colors the animal.

Both males and females produce both androgens and estrogens. Although the female does produce testosterone at very low levels, no otherwise-normal black antelope females are on record. Nevertheless, the low level testosterone production may be what gives all tan blackbuck dark-tipped hairs, with higher levels needed to produce the longer dark tips required for a buck to appear black. Prolonged action even at very low levels may have some effect. In both a Texas zoo herd and a Texas pasture herd it was noticed that one doe had a somewhat darker coat of peppery-tan instead of orange-tan. Schmied (1973) observed the development of a similarly darker coat in the oldest female in his Austrian herd; the change came at 8 to 9 years of age and was retained to the female's death at

12 years 4 months of age. Furthermore, different ages may be characterized by different tissue receptivities such that a testosterone level insufficient to cause dark pelage at a young age might be adequate in an older animal.

In human males, and possibly in antelope bucks as well, the rate of testosterone output increases sharply at puberty, peaks at about physical maturity and then declines much more slowly than it rose (Guyton 1971). Certainly the growth curve for the blackbuck testis through physical maturity suggests this pattern (Fig. 7-6). In any case, testosterone is not stored, so circulating levels should be due to present production. Human testosterone circulates for a maximum of 15 to 30 minutes after secretion in the testes; by this time it has either been fixed in the tissues or degraded into inactive products which are excreted (Guyton 1971).

Summary

Only normal male blackbuck turn black. Age, season and social status, in addition to sex, all interact with the genetic complement of the individual to determine coat color.

Typically, bucks darken during their first fall as mature animals (2-2.5 yr) or during the next fall. Even adult bucks may remain tan, however, if they are continually dominated by other bucks. Territorial bucks, who are superior in rank to all other blackbuck who enter their territories, lighten least during the summer, while bachelors often turn as tan as bucks who have never changed. During the winter, all healthy adult bucks who are not dominated too harshly are at least partially dark.

All blackbuck replace the hair coat twice a year. One coat starts to grow in at the beginning of winter and the next the following late summer.

Dark color is a secondary sexual characteristic in blackbuck. It emphasizes the major sexual and aggressive display. Castrated bucks do not turn dark, grow robust horns, show full development of the preorbital glands or gain the thick neck characteristic of normal adult males. Experiments using bachelor males have linked testosterone levels with both dominance rank and coat color. It is postulated that the yearly cycle of photoperiod changes activates molting in blackbuck through the action of LH and that the effect of social status on testosterone production governs maximum depth of color produced. Superimposed on this pattern, however, is the tendency for a summer lightening in order to mitigate the effects of increased radiation.

8

NOMENCLATURE / SPECIATION

☐ According to the strictest usage, "antelope" means only the blackbuck. However, after Pallas published his 1766 list of antelope forms (*Antilope* in the Latin in which Pallas wrote), both the English and the Latin words were increasingly used to designate any of a heterogeneous group of horned ungulates made up of all those species which did not seem to fit into the familiar and comparatively homogenous groups "cattle," "sheep" and "goats" (Pallas 1767, Pallas *in* Sclater and Thomas 1897-98). To avoid confusion, modifiers were then added to "antelope." Thus, the "antelope" of English writers became the "Indian antelope" and, finally, the "Indian blackbuck antelope" (Sclater and Thomas 1897-98, Lydekker 1907).

The sportsman's term "blackbuck" (written "black buck" by early authors), which characterizes the animal's striking sexual dimorphism, is not without Indian precendent. The Hindi name *kala hiran* translates "black deer" or "black buck" (Brander 1923, Krishnan 1972). Most Indian languages have different names for the male and the female; for example, *kalai* is Tamil for the male blackbuck and *pulvaai* designates the female (Krishnan 1972). These plus other names applied to the Indian antelope in its native countries are given in Appendix E. Finding the German name *Hirschziegenantilope* ("deer-goat-antelope") an unwieldy composite, German authors are especially inclined to substitute the consonant Nepalese name *sasin*.

Opinions differ as to the etymology of the present English word "antelope." Palmer (1904 p. 110) gives in a footnote G. Cuvier's statement in *Règne Animal* that the Latin word *antilope* ". . . is not an ancient name but a corruption of 'antholops' . . . which seems to refer to the beautiful eyes of the animal." However, Palmer (1904) and other English authors like Lydekker (1907) give greater credence to der-

ivation from the Latin *antalopus* which, by way of a late Greek work, designated a horned animal which was probably an antelope. In about 336 A.D. Eustathius of Antioch mentioned an imaginary beast, the antelope, which lived among the banks of the Euphrates and was said to fell trees with its long, saw-like horns and also to use them to tangle itself in bushes (Lydekker 1907, Anon. 1971). This savage beast was supposed to be very difficult to catch (Anon. 1971). There may also be a link with the old Coptic term for the unicorn, *pantholops* (Lydekker 1907).

Classification

Whatever the derivation, Topsell seems to be the earliest author to use "antelope" in its modern sense (Anon. 1971). In *Four-footed Beasts* (1673) he had an entry for "The Antalope called in Latin *Calopus,* and of the Grecians *Analopos* or *Aptolos.*" (Anon. 1971, p. 90). There were still differences of opinion, however. In 1678, Phillips called the antelope ". . . a mongrel beast begotten of a Hart and a Goat." (Anon. 1971, p. 90). Linneaus included the blackbuck in his 1758 edition of *Systema Naturae* as *Capra cervicapra* ("goat deergoat"). Recognizing its closer relationship to many bovid forms other than goats, Pallas in 1766 changed the genus name to *Antilope* following the name *l'antilope* that the French naturalist Buffon had used for the blackbuck (Sclater and Thomas 1897-98). Buffon (1764), in his turn, had merely adopted the current English name for the species. Except for Lichtenstein's 1814 attempt to shift the blackbuck to *Gazella* (Sclater and Thomas 1879-98), there have been no convincing efforts to change the blackbuck's scientific name again. Over the years, all of the other living species placed in *Antilope* have been removed leaving the blackbuck as the sole representative of its genus.

Similarity to gazelles

Lichtenstein's arguments for switching the blackbuck into *Gazella* may be revived in the future because of mounting evidence of the blackbuck's close relationship with gazelles. However, the similarities may have arisen by convergent evolution after the blackbuck's ancestors had already become isolated from the gazelle line. Blackbuck horns spiral instead of curving upward in the simpler gazelline S-shape. Unlike any of the gazelles, blackbuck exhibit a striking dimorphism in depth of color caused by the darkening of many older males.

The argument for similarity is strong because, in spite of their differences, blackbuck look like gazelles. They have the slender, graceful proportions and the small size of gazelles. Their height and weight overlap the lower end of the size range for the tall *Nanger* subgenus of *Gazella,* which includes the dama gazelle in which both males and females permanently change their coat color as they mature. Blackbuck horns bear the same sort of annulations as the horns of gazelles, and all their horns end in smooth, curved tips. The preorbital, carpal and inguinal glands show microscopic as well as macroscopic affinities. One blackbuck among the many observed in Texas even had the same pattern of hair line and whorl on the dorsal neck that most dama gazelles have. Nevertheless, springbok, for example, also look like members of *Gazella,* and yet the special adaptations of springbok are still distinctive enough to place them in a separate genus.

Coloration

Except for the coat being dark in some of the males, Indian antelope are colored like gazelles. There is the same sharp demarcation between tan-colored head, neck, body and outsides of the legs and white belly, rump, chin and insides of the legs. There is no dark flank stripe, but some gazelles lack this also or, like Grant's gazelle, often lose it as they grow older. A pale side streak makes the dark flank stripe below even more striking in those animals that have one. The pale side streak is common, however, as a characteristic feature even of gazelle species with no flank stripe. This side streak is clear in all blackbuck but the darkest males, although it is narrower than in some of the gazelles. Furthermore, blackbuck show traces of a dark tail tip and sometimes even dark ear rims. In addition, blackbuck have a slight darkening along the lateral border of the white rump patch where gazelles often have a dark pygal band. Alternatively, the blackbuck's darkening could be a convergent adaptation for emphasizing a white rump in open country.

The blackbuck's white eye rings which at first glance seem so unique are really a modification of the gazelline face pattern of dark eye stripe flanked with white. Close examination of blackbuck frequently reveals pigmented hairs within the ring along the upper axis of the gazelline eye stripe. Grown blackbuck males are particularly likely to have a triangle of dark hair directly above the eye. Although rarely as sharply demarcated as in some gazelles, both bucks and does normally develop darkening on the nose and along the ridges on the face above the eyes and eye rings after maturity. Even the blackbuck's characteristic hoof spots are not unique. In the adult coat, dama gazelles have marks similar in both placement and shape.

Behavior

Recently, behavioral similarities between blackbuck and gazelles also have been demonstrated. To mention a few, the grazing ritual which ends ritualized fights between blackbuck males is like that described for Thomson's gazelle (Walther 1968). Unlike the generalized form of submissive grazing found among bovids, including blackbuck, and among cervids as well, the grazing ritual ending a fight follows a predictable pattern in the change of spacial relationship and orientation of the two animals involved. Blackbuck perform the "long-foreleg-step," a behavior similar to the "big step" occasionally performed by Grant's gazelle (Walther 1968, 1972a). In addition blackbuck share the combination of "tripping" and steep intention movements for mounting in courtship with Sömmering's gazelle (Walther 1964b). These behaviors appear to form a related series. This, in turn, indicates a relationship with *Laufschlag* as used in courtship by certain other species in the subfamily Antilopinae (Walther 1958, 1964b). Urination and defecation postures of blackbuck match those of gazelles. Blackbuck mark with the preorbital gland the way Thomson's gazelles do. Male Grant's gazelles and male Thomson's gazelles, whose social behavior in the wild has been studied in detail, both establish territories from which the owner excludes male conspecifics or within which the owner dominates them; the owner also tries to keep female conspecifics inside his boundaries (Walther 1972a, 1972c, 1972d). Male blackbuck also keep such territories.

Chromosome structure

The most provocative new evidence of similarity to gazelles comes from studies of chromosome structure. Karyotyping at the San Diego Zoo revealed that blackbuck share with at least seven gazelle species an X-autosome translocation resulting in XY1Y2 male and in XX female types (Effron 1976). Blackbuck also posses five of the eight metacentric chromosome pairs that

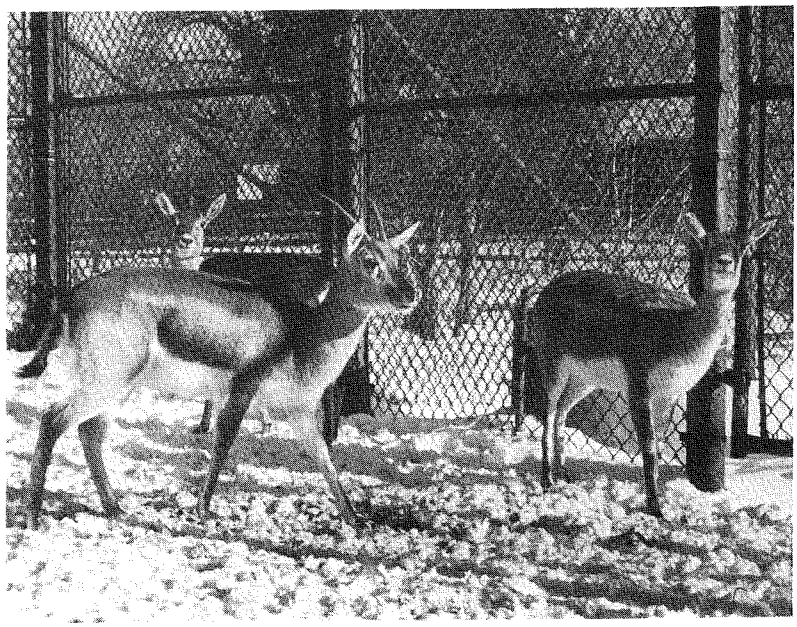
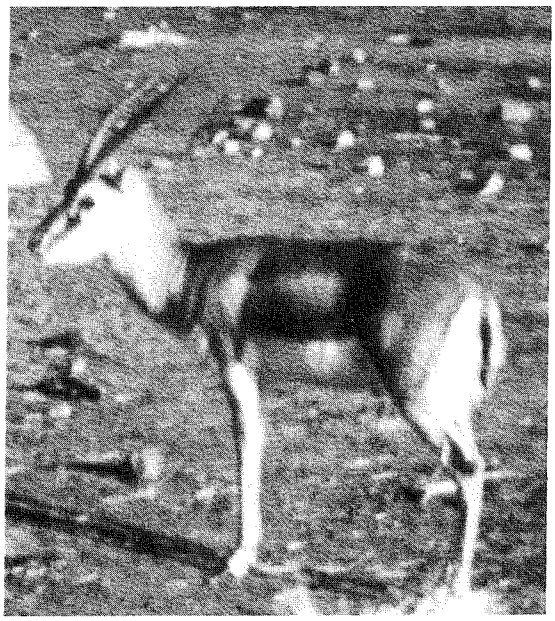


FIG. 8-1. Horned female Thompson's gazelle X blackbuck hybrid with two blackbuck females (right) and male hybrid from the same parents (opposite page). (Photographs courtesy Richard Naegeli and E. E. Schobert, respectively.)

Grant's gazelle and dama gazelle hold in common (Effron 1976). Robertsonian fusion in which two acrocentric chromosomes join to form one metacentric chromosome is widespread among gazelles (Effron 1976). The primitive gazelle chromosome number was probably 60, but Robertsonian fusions during the course of evolution have led to gazelle species with as few as 30 chromosomes (Effron 1976). The three blackbuck tested showed 30 chromosomes in the female, 31 in one male and 33 in another male (Effron 1976). The difference between the male numbers indicates that the 33-chromosome male lacks one Robertsonian fusion shared by the other two. As shown by the impala in Kruger National Park, it is entirely possible for a population to be heterozygous for a Robertsonian fusion (Wallace and Fairall 1967).

The Grant's gazelle karyotype, which also had 30 chromosomes in the female and 31 in the male, was the most similar to that of the blackbuck (Effron 1976). The dama gazelle karyotype with either 38 or 40 chromosomes in the female and with either 39 or 40 in the male was the next most similar. The third member of the subgenus *Nanger,* Sömmering's gazelle, which inhibits Ethiopia and, thus, is sandwiched between the distributional areas of the other two, was not available for testing (Effron *in litt.*).



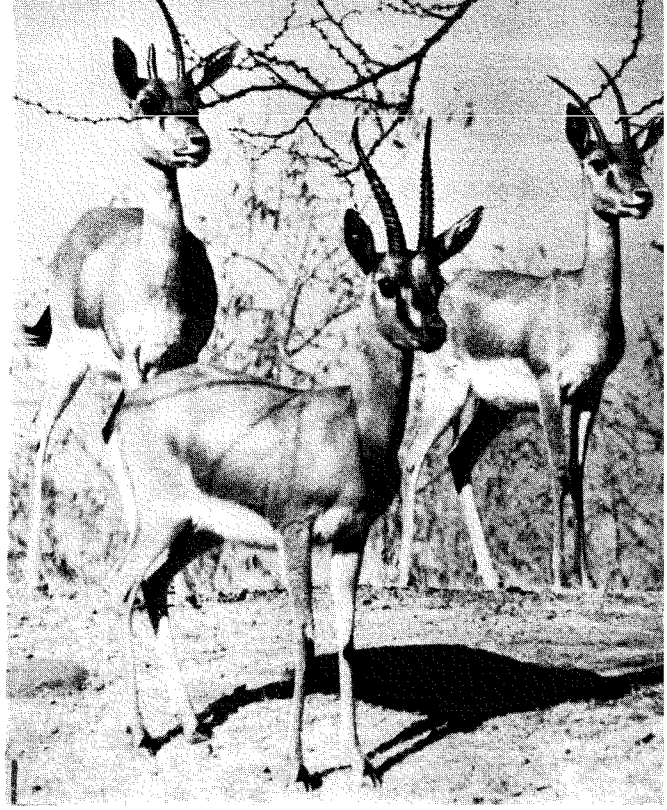


FIG. 8-2. Female chinkara X blackbuck hybrids standing behind their chinkara sire. (Photograph courtesy K. S. Dharmakumarsinhji.)

Hybridization

A physiological resemblance between the blackbuck and the gazelles is demonstrated by cases in which blackbuck have been bred with gazelles. In a blackbuck X Persian gazelle cross, the female became pregnant but died before giving birth (Brehm *in* Krumbiegel 1954). Whether the death had anything to do with the pregnancy is not recorded. Three times a blackbuck doe living with Thomson's gazelles in the Walter Stone Zoo in Massachusetts has given birth to a "tombuck." Of the two fawns raised, the female (Fig. 8-1A) resembles a blackbuck less closely than the male (Fig. 8-1B) (Naegeli and Davidson pers. comm.). Dharmakumarsinhji *(in litt.)* successfully raised two sterile, female hybrids from a blackbuck doe and a chinkara buck (Fig. 8-2). The distributions of blackbuck and chinkara do overlap, and their differences in ecological preferences do not prevent them from coming in contact, but hybridization has never been reported from the wild populations. *Antilope cervicapra* evolved in India whereas *Gazella gazella,* of which the

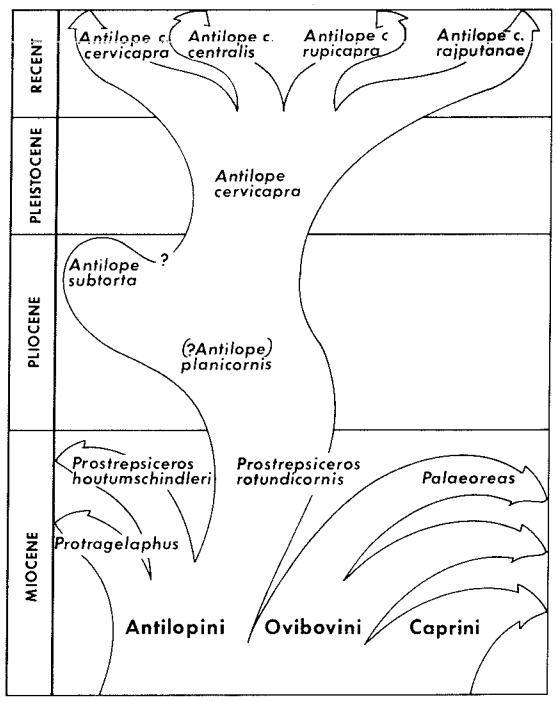


FIG. 8-3. Postulated evolutionary relationships of blackbuck with various fossil forms as proposed in Gentry (1971) and Pilgrim (1939).

chinkara is one subspecies, invaded India comparatively recently (Blanford 1873).

Fossil evidence of ancestry

Today, the blackbuck antelope occurs exclusively on the Indian subcontinent, but fossils of allied species have been recovered from places as far away as Pikermi in Greece, Samos near Turkey, Maragha in Iran and Omo in Ethiopia (Gentry 1970, 1971, 1976).

Miocene descent

From his examination of fossil bovids, Gentry (1971) proposes an evolutionary scheme whereby the blackbuck's genus, *Antilope,* originated from the Miocene (Van Couvering and Miller 1971) genus, *Prostrepsiceros,* which, in turn, derived from the same foundation stock that gave rise to members of the tribes Caprini (goats and sheep) and Ovibovini (musk oxen) as well as the blackbuck's tribe, Antilopini (Fig. 8-3). The extinct *Prostrepsiceros rotundicornis* is the Miocene species most like the living blackbuck and, therefore, is the best candidate for an ancestral type (Gentry 1971). In both, the braincase exhibits only a small degree of bending on the face axis and the horn cores are typically without keels or medio-lateral compression. To a variable extent, some blackbuck horn cores do show vestiges of an anterior keel which has a medial insertion, and this also agrees with the *P. rotundicornis* material. On the average, blackbuck horn cores may be less massive than those of *P. rotundicornis,* but those of *P. rotundicornis* are, in turn, less massive than those of its other Miocene relatives. To judge from Gentry's (1971) plate, the horn spiral in *P. rotundicornis* approximated the most open of the normal shapes occurring in today's blackbuck (Fig. 8-4). It would be most instructive to know the range of variation shown by *P. rotundicornis* in this respect.

Although the horns agree well, the face and dental characteristics of *P. rotundicornis* are unknown. One can only assume that these resembled what is known for *P. houtumschindleri* in which the shape of the nasals plus their contact with the premaxillaries are very like the condition in blackbuck. These similarities, combined with the size and shape of the horns as illustrated by Gentry, give the front view of the *P. houtumschindleri* skull a striking likeness to that of *Antilope cervicapra* (Fig. 8-5). The molars and premolars of the two species display further resemblances, although they do not match. *P. houtumschindleri* had a much more pronounced anterior keel than even those blackbuck that show this feature (Fig. 8-6). Among the other characters distinguishing *A. cervicapra* from *P. houtumschindleri* are the blackbuck's shorter and wider nasals, more hypsodont teeth and lack of a lower second premolar. It differs from both *Prostrepsiceros* species in such features as its very large supraorbital pits, smaller preorbital fossa, relatively wide and low braincase, and short premolar row. Consequently, *Prostrepsiceros* and *Antilope* have been retained as separate genera in spite of the presumed relationship. (Gentry 1971).

Living blackbuck show less similarity to the other spiral-horned antelope genera represented at Samos: *Protragelaphus* and *Palaeoreas* (Gentry 1968, 1971). The group including both *Prostrepsiceros* and *Protragelaphus* is closer to the blackbuck than to tragelaphines, despite the name of the latter (Gentry 1971). The relatively large *Protragelaphus skouzesi* has horns that are too massive, a posterior keel too well developed on the horn cores, horns

FIG. 8-4 (above). Horn spiral in fossil **Prostrepsiceros rotundicornis** cranium from Maragha compared with most open form shown by Texas blackbucks (subadult example). (Photograph of fossil by permission of the Trustees of the British Museum [Natural History].)

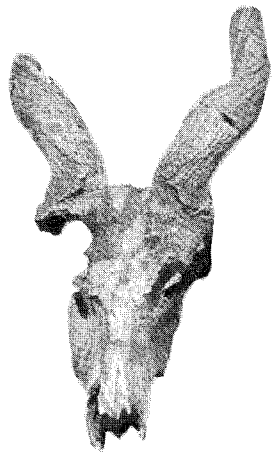
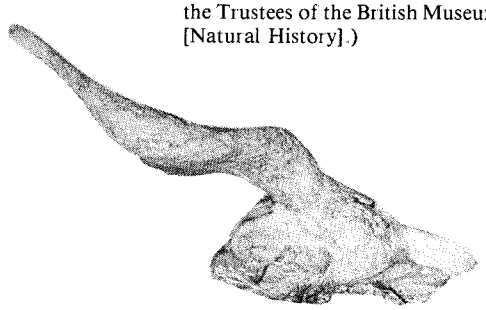


FIG. 8-5 (left). Similarity of **Prostrepsiceros houtumschindleri** from Maragha and **Antilope cervicapra** from Texas in front view. (Photograph of fossil by permission of the Trustees of the British Museum [Natural History].)

FIG. 8-6 (below). Pronounced keel in **Prostrepsiceros houtumschindleri** from Samos compared with moderate keel as shown by some Texas blackbuck. (Photograph of fossil by permission of the Trustees of the British Museum [Natural History].)



inserted too posteriorly, orbital rims not prominent enough, brain case too angled on the face axis and frontals too hollowed — among other differences — to provide a convincing ancestor for blackbuck (Gentry 1971). Differences between *A. cervicapra* and *Palaeoreas lindermayeri* are even greater; they include smaller horncore bases in the blackbuck, thinner cores, lack of a posterior keel, cores that actually spiral instead of just twisting on the axis, orbital rims very pronounced, braincase not strongly angled, longer braincase and poorly developed styles and ribs on the upper molars (Gentry 1971).

Gentry (1971) suggests that, compared to the blackbuck, the line leading to the more ovibovine *Palaeoreas* split away from a different outgrowth of the stock which gave rise to the Antilopini, Ovibovini and Caprini. The line leading from this common ancestral stock to *Prostrepsiceros rotundicornis* had an early offshoot which developed into the genus *Protragelaphus* and a later offshoot which became *Prostrepsiceros houtumschindleri; Antilope* developed from *Prostrepsiceros rotundicornis* at a time later than that part of the Miocene preserved at Samos and other sites of roughly the same age (Gentry 1971). The *P. rotundicornis* fossils found at Samos in the Aegean and at Maragha in Iran are more gracile than the representatives unearthed at Pikermi (Gentry 1971). However, because there is no way to evaluate the normal variation of horn forms, a type of variation which has broad limits in *Antilope cervicapra,* the paucity of the material renders impractical any speculation as to whether the Pikermi material might be earlier.

Pliocene descent

As far as the fragmentary evidence will allow, Pilgrim (1939) attempts to trace the evolutionary history of the blackbuck once its descendants had reached the Indian subcontinent. Discussing the affinities of the Pliocene material, Pilgrim (1939) uses *Helicotragus* as equivalent to *Prostrepsiceros rotundicornis* of Gentry (1971). The species *planicornis* has a weak postero-external keel such as is often found in *Helicotragus* species; nevertheless, its supraorbital foramina have a large supraorbital pit as found only in *Antilope* rather than having small supraorbital foramina like Pilgrim's *Helicotragus* species, so it has provisionally been referred to *Antilope* (Pilgrim 1939). The main differences between (?*Antilope*) *plaincornis* and *Antilope cervicapra* are the former's horn cores with their marked lateral compression, oval cross section, flattened external face, weak postero-external keel and somewhat more open spiral (Pilgrim 1939). In addition, the lower third molar assigned to (?*A.*) *planicornis* is broader and less hypsodont than in *A. cervicapra,* and this fossil molar has a basal pillar (Pilgrim 1939). However, the dental similarities are otherwise great, and Pilgrim (1939) considers that the differences in tooth structure are ones which could be anticipated in a species ancestral to the blackbuck.

By the upper Pliocene, fossils that unequivocally belong to *Antilope* appear. Earliest known is *Antilope subtorta,* whose relationship to the mainline of blackbuck ancestry Pilgrim (1939) was unable to clarify. A trace of a postero-lateral keel persists in the horn cores of *A. subtorta,* and the horn cores make about one-third of a revolution for every whole revolution in the horn form most common among blackbuck today. The lower molars were probably broader and less hypsodont than in *A. cervicapra.* (Pilgrim 1939).

Restriction to Indian subcontinent

One 3-million-year-old horn core and pieces of a second, both discovered at Omo in southern Ethiopia, probably belong to *Antilope subtorta* (Gentry 1976, *in litt.*). This demonstrates that early members of Antilope were not restricted to India. Toward the end of the Pliocene there may have been temporary island links between Arabia and the southern coast of what is now Ethiopia, but this land connection with Africa subsequently disappeared leaving in the Pleistocene only the harsh and narrow Ismus of Suez much farther north (Cooke 1972). *A. subtorta* also disappeared at some time near the close of the Pliocene (Pilgrim 1939). In the early to mid Pleistocene come the first fossils of *A. cervicapra* (Pilgrim 1939). Like the recent representatives, all are from the Indian subcontinent.

Comment on fossil characters

The fossil record is fragmentary, but paleontologists have done much with what is available. Piecing together elements of the evolutionary

history of blackbuck has meant working with teeth and even more with the lower sections of horn cores because these are the types of fossil material that have most often survived in a recognizable form. Therefore, horn size and shape have assumed paramount importance in defining the various groupings, and particular emphasis devolves upon evidence of keels and tightness of spiral. Although the authors acknowledge that partial keels are sometimes present on normal blackbuck horn cores, the papers do not discuss any evaluation of the fairly open spiral characteristic of the fossil forms in terms of the extreme variation of spiral tightness characteristic of living blackbuck. Therefore, the spiral form of the extinct species may overlap one extreme of the range observed among *A. cervicapra* more often than has previously been appreciated. Naturally, this kind of evaluation has a bearing on the taxonomic distance recognized between species and the relationships assumed among them. Extremely open spirals occur in Indian populations (G. 1909) and in exotic populations as well. Among 114 males of 2 years or older from the Edwards Plateau of Texas, three had very open spirals.

Subspecific variation

As the species became established in India, *A. cervicapra* itself differentiated. Using more than 100 living blackbuck of known provenance, Zukowsky (Hagenbeck *in* Ellerman and Morrison-Scott 1966) distinguished four groupings which he called species but which have become accepted as subspecies (Ellerman and Morrison-Scott 1966). The characters stressed were extent of the dark coat markings, degree of horn divergence and tightness of horn spiral as well as number of spiral turns and overall horn length (Ellerman and Morrison-Scott 1966).

Zukowsky made the following determinations (Hagenbeck *in* Ellerman and Morrison-Scott 1966). The nominate race *Antilope cervicapra* (now known as *Antilope cervicapra cervicapra*) is the southernmost form. *A. centralis* (now *A. c. centralis*) lives in the more northern plains of the Deccan between *cervicapra* and the southern limit of *A. rajputanae* (now *A. c. rajputanae*) which inhabits Rajputana and the Punjab. And *A. hagenbecki* (superceded by

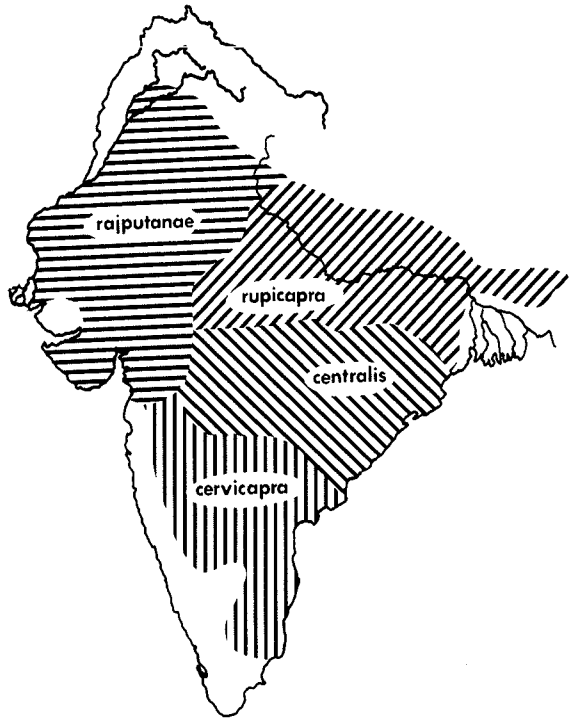


FIG. 8-7. Distribution of the four subspecies of **Antilope cervicapra** of Zukowsky. (Dividing lines are approximate.)

Muller's [Muller *in* Ellerman and Morrison-Scott 1966] *Antilope rupicapra* and, thus, now known as *A. c. rupicapra*) is found in the United Provinces nearly as far west as Agra (Fig. 8-7). Therefore, the subspecies extending to the foothills of the Himalalayas in Nepal is *A. c. rupicapra,* and the subspecies once common in Pakistan east of the Indus and its tributaries the Jhelum and the Chenab is *A. c. rajputanae.* Groves' (pers. comm.) recent reexamination supports the existence of a northwestern population subspecifically distinct from the blackbuck to the east and south, but not enough southern material was available to reevaluate postulated differences between the eastern and southern animals. However, Groves includes *centralis* under *rajputanae.*

Cline in coat color

Zukowsky states that the extent of dark coat markings is greatest in *A. c. rupicapra,* one of the two northern subspecies, and least in *A. c. cervicapra,* the southernmost subspecies (Hagenbeck *in* Ellerman and Morrison-Scott 1966). This cline may be related to the colder temperatures just south of the Himalayas and the hotter climate of the Thar desert (in Rajasthan) and

the Deccan plateau. (For further discussion, see Chapter 7.)

Not all authors agree that there is a cline in depth of dark color (Krishnan 1972), but comments scattered through the literature generally corroborate the feeling that there are more mature bucks of a darker hue in the north than in the south (Lydekker 1907, Simmonds *et al.* 1923, Stockley 1928, Prater 1971). The uncertainty probably arises from an incomplete realization as to all the factors which must be reviewed in order to evaluate the dark coat color. Season, state of health and dominance rank must be considered in addition to the obvious variable, age. For a full discussion of these variables, see Chapter 7.

Clines in horn length and body size

According to Zukowsky, the longest horns and the tightest spiral occur in *A. c. rajputanae* and *A. c. centralis;* the shortest and most open are in *A. c. cervicapra* (Hagenbeck *in* Ellerman and Morrison-Scott 1966). Average body size also decreases from north to south (Dharmakumarsinjhi and Gaikwad 1958, Krishnan 1972). *A. c. cervicapra* occupies the southern extreme of the species' distributional area. This race may never have penetrated to the very tip of the Indian subcontinent (see the discussion of distribution in Chapter 2). To judge from the population at Point Calimere, it is the wetter climate and heavy mortality due to periodic cyclones and flooding (Stacey *in* Daniel 1967) that limit the species in the south. The shorter horn average and the smaller body size may be a result of less optimal conditions which depress growth or lower average longevity or both. Conversely, the drier areas dominated by *A. c. rajputanae* and *A. c. centralis* seem to favor growth and possibly promote survival such that taller, heavier antelope with longer horns are more common.

Horn spread and spiral

Even if linked to a cline in horn spread with the smallest average divergence in *A. c. cervicapra,* the cline in tightness of spiral is hard to explain unless Zukowsky (Hagenbeck *in* Ellerman and Morrison-Scott 1966) happened to sample an *A. c. cervicapra* population in which the activities of one or more extremely dominant bucks with open-spiral horns had resulted in a population with more than the expected number of bucks with open spirals. In Texas there are such concentrations. Furthermore, the extremely open spiral in Texas bucks tends to be linked with a narrow spread, whereas the extremely tight spiral tends to be linked with a wide spread.

Summary

According to strictest usage, "antelope" means only the blackbuck. Linnaeus designated it *Capra cervicapra,* and in 1766 Pallas changed the genus name to *Antilope.* As the usage of "antelope" broadened to include a heterogeneous assortment of horned ungulates that are neither cattle, goats nor sheep, modifiers were increasingly inserted. Thus, the "antelope" became the "Indian blackbuck antelope." Indian languages have no equivalent for "antelope" as defined in the broad sense. For instance, *kālā hiran,* as literally translated, could be either "black antelope" or "black deer."

The blackbuck's closest relatives are the gazelles. Blackbuck share with various gazelle species many striking similarities. In addition, blackbuck have been successfully mated with gazelles.

Fossils of species allied to the blackbuck have been recovered from places as far away as the eastern Mediterranean, Iran and Ethiopia. The extinct Miocene species *Prostrepsiceros rotundicornis* differentiated from stock ancestral to goats, sheep and musk oxen as well as blackbuck. By the upper Pliocene, fossils that unequivocally belong to *Antilope* are present. First came *Antilope subtorta* whose exact relationship to *A. cervicapra* is unclear. In the early to mid Pleistocene *A. cervicapra,* first exclusively Indian species of *Antilope,* appeared.

Coat color, horn length and horn shape have been used to divide *A. cervicapra* into four subspecies: *Antilope cervicapra cervicapra* in south India, *A. c. centralis* in central India, *A. c. rupicapra* in northeast India and into Nepal and *A. c. rajputanae* in northwest India and into Pakistan. Modern reevaluation upholds at least a northwestern race and an eastern to southern race. Temperature and moisture differences may explain the observed clines in dark color, horn length and body size.

9

FOOD HABITS/PREDATION

☐ Blackbuck are plains grazers preyed upon principally by plains predators. In spite of the blackbuck's heavy reliance on grasses, however, leaves, pods, flowers and fruits normally form a major portion of the diet during part of the year.

Feeding habits

Blackbuck are principally grazers, but they also take browse. They favor the newer, more succulent growth and the short to mid grasses rather than the taller ones. For instance, blackbuck, particularly fawns, will bed in areas of the tall, perennial grass *Desmostachya bipinnata* which is widely distributed throughout India, but feeding blackbuck leave this plant untouched (Oza and Gaekwad 1974). Certain forms of mast, like the legumes of *Prosopis juliflora* in India (Dharmakumarsinhji 1967) and *P. glandulosa* in Texas, are eaten or even sought after, as are various flowers. Although highly preferred, these plant parts do not ordinarily form a major portion of the diet. Berwick (1974) postulates that such parts provide supplemental sources of necessary minerals like calcium and phosphorus which drop to extremely low levels in the grasses during the hot dry season, the time when so many fruits are eaten. In India, the blackbuck's liking for the fruits of the wild bitter-gourd and ripe bael fruit was often their undoing; nooses would be staked out in gourd patches and vicious hooks imbedded in the bael fruit to capture the animals (Krishnan 1972) (see Chapter 2).

Except when thrashing vegetation, blackbuck are reported to damage only one kind of tree. When the sap is running, the adults shred the bark of young willows with their incisors (Taibel 1937).

Consistent with the arid nature of their habitat, blackbuck prefer the more xerophytic plants (Berwick 1974). For example, *Acacia*

leucophoea was the second most preferred plant for blackbuck foraging in the Gir Forest but fifth for axis deer, sixth for sambar and ninth for nilgai (Berwick 1974). Having smaller mouths, blackbuck also seem better able to deal with plants bearing small thorns than are sambar and nilgai which rely less on such forage (Berwick 1974).

In addition to differences in habitat selection and plant preferences, blackbuck exhibit differences in feeding behavior. For example, they stay in a tighter group while grazing than do chinkara (Dharmakumarsinhji 1967). An individual blackbuck takes browse that happens to be growing along its grazing route, whereas a chinkara foraging in the same area often goes directly from one browse plant to the next (Dharmakumarsinhji 1967). The chinkara groups also tend to move along more slowly and to have longer foraging bouts than blackbuck (Dharmakumarsinhji 1967). Krishnan (1972) reports blackbuck scraping in soft earth with forefeet and muzzle to reach underground plant parts, but digging behavior remains to be confirmed from close range.

Although some species, including chinkara (Dharmakumarsinhji 1967) and axis, occasionally rear up on their hind legs to browse when leaves are gone from the lower branches, blackbuck almost never do. Records from more than 30 months of field observation in Texas show just one member of a female group who reared up by an ashe juniper bush and pulled at the growing tips of a branch. In the San Francisco Zoo a doe who had been crowded to the back by the other animals finally reared several times in succession to reach peanuts offered by visitors (Mungall pers. obs.). Neither of these antelope used any leg support. A dark male in the Zurich Zoo who would rear to eat tree leaves quit once green foliage placed on the ground was added to the diet supplied by zoo personnel (Benz 1973). Since bipedal browsing is practically absent in blackbuck, they can browse only to about 30.5 cm (12 in) into a bush or tree (Mirza and Waiz 1973) and 1.2 m (49 in) above the ground, the latter figure being the maximum height when head and neck are fully extended (Dharmakumarsinhji 1967). Taller animals plus those who can reach higher when on the hindlegs can all out-compete blackbuck for browse.

Despite certain parallels, like the occurrence of *Aristida* and *Prosopis* among the forage plants of blackbuck in both Texas and India, it is the types of plants rather than the species which are important. Therefore, food habits are discussed in terms of forage classes. The three used by blackbuck are grass, which includes grass-like sedges along with the true grasses; browse, which consists of leaves, fruits, seed pods and other parts of tree-bush forms; and forbs, which are broad-leafed annuals, including vines. "Palatability" is an index of frequency eaten in relation to frequency of occurrence; a highly palatable plant is one eaten much more often than its availability to the animal would suggest.

The range of species eaten is also significant because animals which will take more kinds of plants may be better able to adapt to changing conditions or to new environments than those animals with restricted diets. Comparing six major ruminants in India's Gir Forest, blackbuck and chinkara diets are intermediate between those of nilgai and four-horned antelope, which are the most varied, and axis and sambar, which are the most restricted (Berwick 1974). Of 30 plant species identified on a dry-season site, a Pakistan blackbuck herd was offered 22 in feeding trials and ate 19; nevertheless, 5 accounted for most of the eating time and 2 of these 5 occur only at very low densities in native habitat (Mirza and Waiz 1973). Appendix F lists plants various workers have seen blackbuck eat. However, none of the studies from which this table was compiled attempts to give all known foods, so it should be viewed as representative rather than complete.

India

As the grazing in India deteriorates before the monsoon season, blackbuck become increasingly dependent on browse. Which species are sprouting new leaves and growing vigorously determine which are preferred. Thus, the dramatic change in vegetation after the first monsoon rains brings a quick change in diet, as large quantities of fresh sprouts become available again.

Where blackbuck are too numerous to be supported by the natural grassland, they will enter young stands of grain or other crops in the evening and defy efforts to chase them away

(Forsyth 1871, Stockley 1928, Dharmakumarsinhji 1967). If unmolested, many remain in the fields all day instead of leaving in the early morning (Forsyth 1871). Young wheat is commonly invaded (Forsyth 1871, Stockley 1928), and Baker (1890) mentions that blackbuck seem to favor such stands when the wheat is about 23 cm (9 in) tall.

Just how much damage they do is open to debate. Baldwin (1876 p. 197) describes the crops as ". . . often fed quite close off by hundreds of antelopes during the night." However, Krishnan (1972) notes that inhabitants of a largely agricultural village in Orissa where blackbuck have been protected for generations report loss due to blackbuck is negligible. Similarly, Krishnan (1972) was told at Point Calimere that pigs and axis deer, rather than blackbuck, were threatening agriculture. This is in spite of Point Calimere Sanctuary harboring the largest blackbuck population known in south India (Daniel 1967). Thus, Krishnan (1972) suspects that, at least in some cases, blackbuck depredations have been magnified to justify killing for meat.

Food habits of blackbuck in their native habitat are summarized here. Except as noted, the information is drawn from Dharmakumarsinhji's (1967) 3-year feeding study using both captive and wild subjects. For the captives, use of both naturally occurring and cut food was evaluated. Supplementing these observations, as noted, are data gathered by Berwick (1974), who worked for more than a year in the Gir Forest studying the ecological relationships among large ruminants. Blackbuck have not been seen in the open flats of the east Gir Forest itself for some 30 years, but there are still a few close by in small, isolated populations (Berwick 1974). Even though he had no wild blackbuck specimens to observe, Berwick (1974) had captives for his bite studies and his cafeteria trials.

Indian monsoon — July through October: During the monsoon blackbuck spend more time grazing than browsing. They attack new blades avidly as the rains bring a ground cover of grass. The *Aristida* that blackbuck eat is nourishing during the monsoon when green. Both *Aristida redacta* and *Apluda varia,* which blackbuck also eat, remain abundant into August. At the close of the monsoon and on into the winter, blackbuck will use the tall grasses.

There is a low level of browsing at the beginning of the monsoon when the rainfall is greatest; the mature trees offer little after the heavy summer use. When the first rains knock down legumes that have remained hanging after drying, they are eaten promptly. Mud prevents the antelope from obtaining much browse from the ground, and whatever is not taken as soon as it falls rots.

Plants are taken as they sprout. Thus, browsing intensity remains low on all but those species that respond to the rains by leafing out and growing rapidly. Within about 10 days, *Acacia senegal* and most of the other acacias show new leaves. The blackbuck are attracted to them at once. *Acacia arabica, Salvadora* and *Mimusops* are favored by the antelope. Forbs also spring up at the start of the rains and are eaten by the blackbuck.

Indian winter — November through February: Use of tall grasses continues into the winter until even these grasses are depleted. Grass cover virtually disappears sometime after November. The animals eat what little new growth there is during the winter. Some mature trees are just coming into leaf, and if these have drooping branches the blackbuck frequently browse on them. Many other trees are losing their leaves, and some go bare altogether. Since the ground is drying now, blackbuck can eat the fallen leaves and mast. Stems are also chewed. Toward the end of winter certain flowers appear. Blackbuck sometimes loiter under trees in flower and eat the blossoms that fall. Since small animals like roseringed parakeets and striped squirrels often drop legumes or flowers they have been feeding on, their arboreal activities make these foods more available to the blackbuck on the ground. Fresh browse starts to appear again in February.

Berwick never found grass protein levels above 3 percent in the Gir Forest. For the two major grasses, *Apluda mutica* and *Sehima nervosum,* winter determinations were very low — 2.6 percent and 2.5 percent, respectively. Browse plants maintain a high level of crude protein — over 10 percent — from the beginning of winter until January; then the value declines to approximately 4 percent as the old

leaves drop. From January to March, the wild ruminants of the Gir supplement their diets of grasses and browse plants with fruits. The animals seem to seek out the abundant fruits of plants like *Diospyros melanoxylon* and *Emblica officinalis.* (Berwick 1974).

Indian summer — March through June: At least one tree flowers on into the summer, and the blackbuck are just as partial to its flowers then as in the winter. What specimens of grasses, such as *Apluda mutica* and *Sehima nervosum,* that can be found are now even lower in protein — 2.1 percent and 1.8 percent, respectively (Berwick 1974). Calcium and phosphorus content in these grasses also drops (Berwick 1974). During a dry-season study in Pakistan the blackbuck left untouched the dry blades of a common grass (Mirza and Waiz 1973) that they had eaten avidly when it was sprouting during the rains (Bokhari 1970).

Fortunately, many browse plants begin to grow during the summer, and their protein values increase (Berwick 1974). Browsing intensifies as more of the palatable species sprout. Blackbuck nibble drooping branches in leaf when they can reach them. Because of increased browsing pressure as the hot dry season progresses, browse at the lower levels is gone by the end of summer.

Texas

Blackbuck are mainly grazers in Texas as well as in India, but they also do a substantial amount of browsing wherever deer or other browsers do not out-compete them for this forage class. Only in summer, however, does browse equal or surpass grasses in the diet (Fig. 9-1).

The Texas Parks and Wildlife Department staff of the Kerr Wildlife Management area determined these relationships from a bite study (investigation carried out under Pittman-Robertson Project [Federal Aid] W-76-R, Kerr Wildlife Management Area Research). Starting when she was a year old, a blackbuck doe was taken four times every month to each of three different types of sites (Fig. 9-2). One area was used by no other hoofed animals; another was used only by native white-tailed deer; the third was used heavily by cattle and sheep as well as whitetails. The following summary of blackbuck food habits in Texas is based on the overview of this study in Cary (1976a).

To a certain extent the use patterns reflect the general composition of the vegetation. Nearly 30 grass species were seen eaten; a plant survey of a nearby pasture in the same vegetation zone found a total of 40 grass species (Cary *et al.* 1975). Similarly, the blackbuck ate from 15 browse species; the plant survey tallied 16 kinds of trees and bushes (Cary *et al.* 1975). Even though the survey found 104 forb species (Cary *et al.* 1975), these typically occurred only at low densities. They sprout quickly in the spring and remain numerous during the summer, but few grow in fall and winter. Blackbuck eat forbs in relation to their availability instead of relying on them as important food items the way white-tailed deer do (for rumen analyses of whitetails on the edge of the Hill Country, see Kelley 1970).

Of the grasses taken, more than half had numerous observations. Of the browse plants, however, live oak use predominated at all times of year and in all stocking combinations. In part, this may indicate a preference for oak

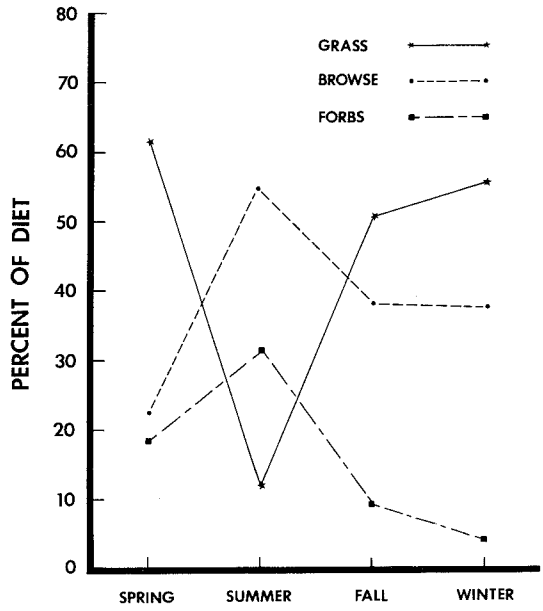


FIG. 9-1. Relative proportions of grass, browse and forbs in diet of a blackbuck female on the Edwards Plateau. (Graph courtesy Texas Parks and Wildlife Department; investigations carried out under Pittman-Robertson Project [Federal Aid] W-76-R, Kerr Wildlife Management Area Research.)

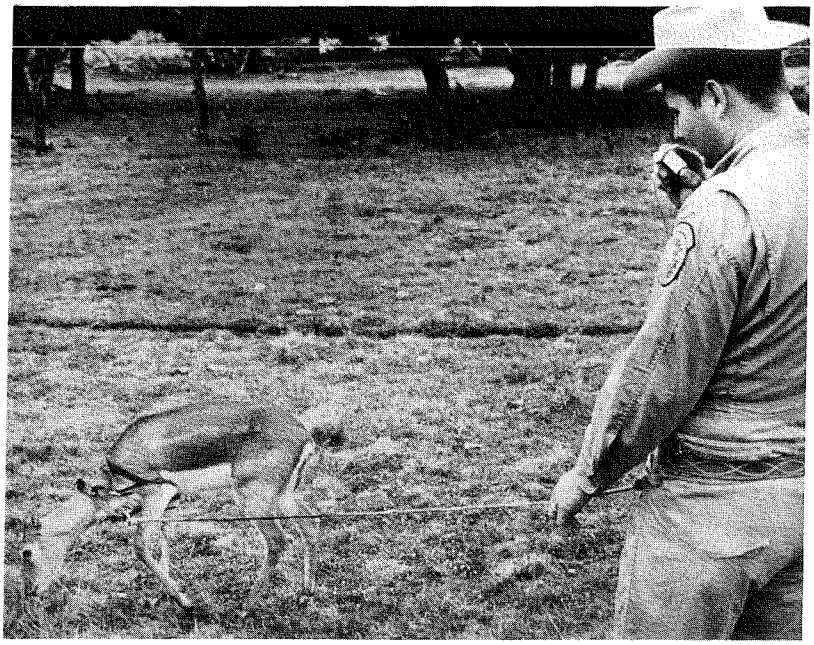


FIG. 9-2. Texas Parks and Wildlife Department researcher recording plant species selected by blackbuck doe during trial in bite study. (Photograph courtesy Texas Parks and Wildlife Department; investigations carried out under Pittman-Robertson Project [Federal Aid] W-76-R, Kerr Wildlife Management Area Research.)

leaves and acorns. Schmied (1973) emphasizes that the blackbuck he observed in Austria ate oak leaves more readily than the leaves of all other local trees; they took acorns freely even though they would not eat fallen horse chesnuts. However, the Austrian herd lives on the boundary between dry oak forest and wet beech forest (Schmied 1973), so oaks would be presumed to be more abundant than most other tree species. On the Edwards Plateau where the bite study was done oaks are also numerous and the live oak is one of the dominant tree species. Moreover, live oaks change their leaves later in the year when animals have more alternative forms of browse available. Thus, browsing pressure is lower and live oak leaves are more likely to remain where blackbuck can reach them (Anderegg pers. comm.).

Texas summer — June through August: Blackbuck are mainly grazers except in summer when there is a definite shift to browse. The increasingly hot and dry weather may correlate with a decrease in the quantity and the nutritional value of the grasses during the summer. Forb use also increases, although to a lesser degree. Where white-tailed deer or other browsers or forb eaters are present, the blackbuck find fewer of the summer broad-leafed plants; this reduces the summer peak in forb use. Faced with heavy competition from both browsers and grazers, blackbuck consume smaller amounts of browse and forbs. For example, blackbuck on ranges overstocked with a combination of cattle, sheep and deer graze and browse about equally in summer, and forb use rises very little over the spring level.

Texas fall — September through November: Late summer and early fall bring rain, and the blackbuck graze more. The pressure on browse starts to decline. Meanwhile, forb use sinks even more quickly. Where there is no competition from deer or domestic browsers, forb use continues at a low level consistent with the small number of forbs growing at this season. Under heavy competition from either, however, blackbuck rarely eat a forb until spring when weedy annuals appear in quantity again.

Texas winter — December through February: Blackbuck depend principally on grazing during the winter. Nevertheless, there is a substantial amount of browsing and a low level of forb use wherever these two forage classes are available. Both on ranges used by deer and on those overstocked with a combination of cattle, sheep and deer, the winter blackbuck diet soars to greater than 90 percent grazing; browsing is minimal. As under fall competition, few forbs are taken.

Texas spring — March through May: Spring patterns remain similar to those of winter until

rains and warmer weather bring new growth and scatter forbs throughout the pastures. Forb use climbs rapidly if other animals are not concentrating on this forage class. If they are, then blackbuck use remains slight.

Drinking habits

In the early literature there is confusion as to whether blackbuck use standing water. In recent times blackbuck in both India and Texas have been observed drinking.

India

Not seeing blackbuck troop to water regularly at dawn and dusk like axis deer and barasingha, Schaller (1967) wondered if blackbuck in India never drink. Regardless of whether they do drink in certain districts, Blanford (1888-91) believed drinking is not obligatory. Otherwise, he pointed out, how could antelope survive in such abundance in Orissa on the 50-km (30-mi) spit of sand between the salt Chilka Lake and the sea. Although now there are the irrigation ditches of casuarina plantations (Schaller 1967), Blanford states that the only fresh water there in his time was from wells. Lydekker (1907) supports him in maintaining there were no irrigation canals or troughs for cattle then.

Others, both past and present, have noted blackbuck drinking regularly during the hot season. Baldwin (1876) speaks of them going twice a day to pools or rivers. Dharmakumarsinhji (1967) in his feeding study on penned blackbuck and chinkara recorded summer watering at and before sunrise, in the afternoon and sometimes after the sun had set.

Texas

With water readily available, Texas blackbuck drink. Observations in Texas indicate several causes for the historical confusion over whether blackbuck use standing water. Since rain leaves temporary pools and puddles in the pastures as well as water which remains even longer in depressions on the upper surface of rocks, blackbuck are not always dependent on man-made tanks. As already noted for India, they do not visit water frequently except during hot weather. There is no fixed time for watering, even though most of the daylight observations fell between 1100 and 1600 hours. They do not usually trek to water in large groups. Instead, animals in larger groups will break off a few at a time and go drink. They go quietly, drink briefly and leave again with no fuss. Finally, the tan females and immatures of both sexes can be difficult to observe against the bare ground and pale rock around ponds if they come as they often do during the middle of the day when the sun is strong.

The behavior of the blackbuck in the vicinity of water is qute unobtrusive. They approach a pond or trough in single file pacing calmly and directly to the water. At a pond where there is room to spread out, individuals drop out of line and step to the waterside as the file moves along the bank. Only when a small trough restricts the space do they drink in a tight group. In such cases, the animals jostle against each other and exchange threats. At a pond, blackbuck go down to the water's edge, lower their noses to the water and drink for approximately 30 seconds without raising their heads. The file reforms as the antelope finish and retrace their steps back the way they came.

Predation

Blackbuck are adapted for life on open plains and scrublands. These antelope rely heavily on sight to warn them of disturbance, and they flee to escape. Two adaptations are of particular importance in helping the species survive the heavy toll taken by predators. On the one hand, many young are born, particularly during favorable seasons. On the other, the network of territorial neighbors (*cf.* Walther 1969 for Thomson's gazelle) and the large herds offer the safety of numbers to all but lone females who have separated for parturition and the first days of motherhood (Dharmakumarsinhji *in litt.*).

India

Blackbuck, often hailed as the fastest long-distance runners, were preyed upon principally by cheetah (Brander 1923, Gee 1969), the fastest short-distance runners. Budden (1921) clocked a doe at 53 km/h (33 mph); a herd kept easily in front of Krishnan's (1972) vehicle at 64 to 72 km/h (40 to 45 mph). Nevertheless, this is not fast enough to evade the initial sprint of a

cheetah if it has been able to creep close in preparation for its rush. A cheetah can attain 72 km/h (45 mph) in the first 2 seconds (Bourlière 1967). Before tiring, it can cover 366 m (400 yd) at speeds as high as 106 km/h (66 mph) (Prater 1971). One individual managed a distance of 640 m (700 yd) in 20 seconds; *i.e.,* more than 114 km/h (71 mph) (Bourlière 1967). Because a blackbuck can run on for 5 km (3 mi) or more (Krishnan 1972), however, the cheetah must make its catch during the first dash or give up with nothing. A cheetah brings its quarry to the ground either by hooking a dewclaw into its hindquarter or by knocking its feet from under it; the cheetah then grabs its prey by the throat in a stranglehold (Prater 1971).

Wild pigs (Daniel 1967), wolves and smaller predators including jackals, foxes, eagles and pariah dogs kill many fawns (Baldwin 1876). In its native desert and scrubland habitat, the caracal also preys on antelope (Prakash 1975). Village dogs are especially destructive because packs will search systematically through patches of cover eating neonate antelope fawns as well as the young of other animals such as hares (Baldwin 1876). However, older fawns are fleet enough to outdistance all but swift dogs (Baldwin 1876).

Even greyhounds rarely can pull down an adult buck in reasonable condition, unless the ground is soft with sand or mud (Baldwin 1876, Brander 1923). It even takes a fast dog or a good horse to catch a buck with a broken foreleg (Baldwin 1876, Baker 1890, Brander 1923). Hamber (1924) was understandably surprised to see a small jackal pull down a buck. The jackal kept going for the back part of the stomach and, although unaided, eventually disabled its victim; this buck showed no signs of previous injury (Hamber 1924). Krishnan (1972) considers that jackals prey chiefly on very young blackbuck.

Wolves prey on adults as well as fawns. Only a few years ago, a pair of wolves killed an albino buck in Velavadar Sanctuary (Dharmakumarsinhji *in litt.*). Watching an Indian digging cubs out of a wolf den, G. (1909) was impressed with the quantity of blackbuck remains, including the skin of bucks, brought to light.

Although they may take a blackbuck occasionally if opportunity offers, tigers are not a serious threat. In Kanha National Park, which is not open enough to be typical blackbuck country (Gee 1969), 2 out of 228 kills likely to be the work of tigers were blackbuck (Schaller 1967). Tigers favor jungles, forests and swamps, so not many blackbuck are available to them. Moreover, common tiger prey like axis, sambar and gaur (Schaller 1967) repay the hunting effort with a bigger meal.

Leopards rarely take a blackbuck, either (Brander 1923, Dharmakumarsinhji pers. comm.), even though these cats can thrive in open country as well as in forests (Prater 1971). Their habit of lying in wait for their prey rather than trying a fast or sustained chase is ill suited to securing blackbuck where cover is scant.

As blackbuck populations have declined in India, two of its major predators have disappeared — the Indian cheetah entirely and the plains wolf locally. Today, jackals seem to be the main animals that take blackbuck. Therefore, predator pressure is concentrated on fawns in the lying-out phase. (Krishnan 1972).

Texas

Coyotes are known to prey on blackbuck. In south Texas they have even run adults into fences and killed them (Robinson pers. comm.). Heavy predation on fawns is believed to be what has kept blackbuck populations on the South Texas Plains from expanding to rival the number on the Edwards Plateau where predator control has been more strict. Although wild pigs, sometimes of mixed lineage, roam parts of Texas, they have not been specifically charged with killing blackbuck fawns.

Raptor predation has not been observed in Texas, either. Baldwin (1876) includes eagles in his list of animals that take blackbuck fawns in India, but Dharmakumarsinhji (*in litt.*) does not consider these birds a significant menace there. Nevertheless, a Texas female with a neonate fawn will spring up at the approach or the noise of a flying object such as a vulture, a large hawk or a small plane. Blackbuck females without young do not react to the bird's presence even in the presence of an alarmed mother. A turkey walking on the ground does not elicit an alarm response.

If an eagle or a large hawk alights in the vicinity of the neonate, the mother stares fix-

edly toward it and may jerk her nose downward as she gives a sneeze call. If the raptor flies low or lights on the ground, she lunges after it. These chases may last for several hundred meters until the bird leaves the open area. Once a mother nearly caught up to a large hawk that settled in the grass. As the doe lowered her head while closing the last few meters, the bird finally took off and left. A doe that Fuchs (pers. comm.) describes as kicking out with its forelegs at an eagle that was repeatedly diving and climbing may also have had a fawn nearby.

Other observations

A doe with a young fawn also becomes aggressive toward dogs (Taibel 1937) and certain other animals. Such females at the Austrian experiment station near Vienna kept rheas away from their fawns, enforcing the restriction with chasing and butting (Schmied 1973). At this same institute, a buck from the Frankfurt zoo attacked a large German shepherd whenever the dog ran into the meadow (Schmied 1973). A jackal X dog hybrid at the Italian experiment station at Rovigo escaped one night and killed a grown blackbuck male (Taibel 1937).

Summary

Blackbuck are principally grazers, but they also take browse. They favor the more succulent growth and the short to mid grasses rather than the taller ones. In spite of certain parallels like the occurrence of *Aristida* and *Prosopis* among the forage plants of blackbuck in both Texas and India, it is the types of plants rather than the species which are important for survival.

The three major types selected by blackbuck are grass, browse and forbs, Blackbuck concentrate on grass during its major growth periods. Then they shift to browse if it is within their reach. They supplement this diet with forbs in relation to their abundance. The antelope actively seek out certain kinds of mast, flowers and fruits which are often available only for brief periods.

Comparing blackbuck predators, Texas has no open plains feline equivalent to India's cheetah. Formerly, the cheetah was the blackbuck's principal native predator, but as blackbuck populations declined, the cheetah became extinct in India. The wolf has disappeared locally in India and is virtually extinct in Texas (Davis 1974). The fox genus *Vulpes* includes the red fox which is a native in India and an exotic in Texas (Prater 1971, Davis 1974). However, the main fox species inhabiting the parts of Texas where blackbuck numbers are highest is *Urocyon cinereoargenteus* rather than a species of *Vulpes* (Davis 1974). The ubiquitous Texas coyote fills the role of the Indian jackal. Today, the blackbuck's chief predators are jackals in India and coyotes in Texas.

10

VETERINARY CONSIDERATIONS

☐ On the whole, blackbuck are fairly free of serious health problems as long as nutrition is adequate and densities remain low. Nevertheless, there are a number of conditions of which the wildlife manager should be aware.

Parasites

Maintaining animal numbers at or below the area's carrying capacity is the best insurance against parasite problems in blackbuck. This obviates the dependence on supplemental feed, with all its attendant difficulties brought on by artificial crowding, and should result in a healthier population. Animals in good condition do not normally harbor parasite loads as high as those to which animals in poor condition are susceptible (Robinson pers. comm.).

Many of the large number of parasites recorded in blackbuck (see Appendix G) are of types probably not of great concern in the management of this species. However, there are some types which should be taken into consideration because they can pose problems which may prove insurmountable in many management schemes.

Trematodes

One group of parasitic diseases to consider are those produced by trematodes or flukes. Of the species reported in blackbuck, only the deer fluke of North America, *Fascioloides magna,* would be considered a potential hazard to management. This fluke, which has a pathogenic effect on the blackbuck, is a species not found in blackbuck in their native land. It migrates into and through the liver, but, in an abnormal host like the blackbuck it does not appear to form the cyst that typically is formed in the liver of a white-tailed deer. The wanderings of this fluke through blackbuck liver parenchyma result in extensive hepatic damage and in a

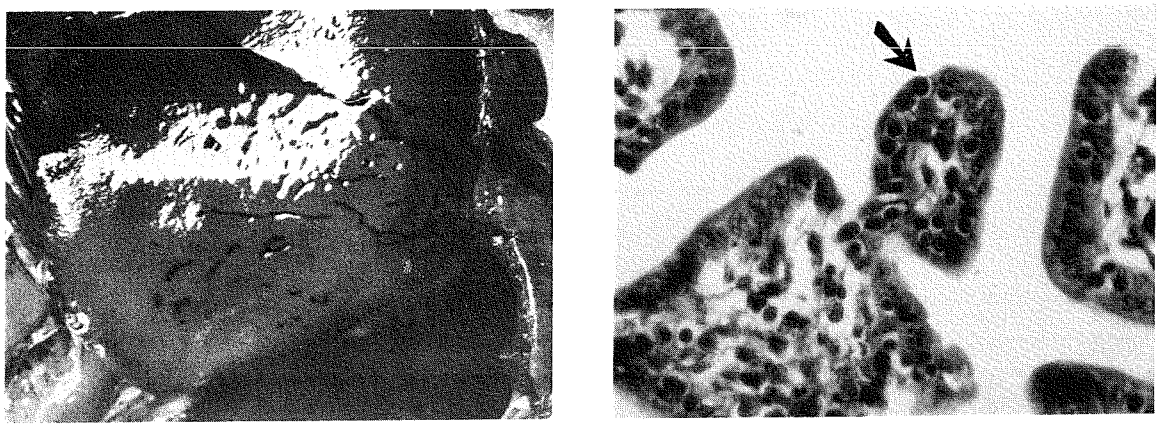


FIG. 10-1. Parasitized blackbuck tissues: (left) pigmented scars in the liver resulting from infection by the deer fluke, **Fascioloides magna,** and (right) coccidiosis in a fawn — transverse section (100X) through the villi of the small intestine shows numerous gametocytes (arrow), large cells with clear area around darkly-staining center, lodged in walls of the villi.

chronic, debilitating disease (Fig. 10-1A). In some areas where blackbuck share range with white-tailed deer, this fluke may become a limiting factor by restricting the ability of blackbuck to multiply and thrive.

Cestodes

Cestodes usually do not constitute a hazard in terms of clinically affected animals. Infections of *Thysanosoma actinioides* would offer the only potential problems to be expected from any of the cestodes reported in blackbuck. To date, however, no clinical cases of infestations by this tapeworm have been reported. Condemnation of infected livers from carcasses to be utilized as food constitutes the primary type of loss caused by these parasites.

Nematodes

The largest group that potentially threatens management efforts is the nematodes. Four genera — *Camelostrongylus, Haemonchus, Ostertagia* and *Trichostrongylus* — are found in the abomasum. These parasites occur on or near the mucosa where they either attach and suck blood or feed on tissues and exudates. Anemia, hypoproteinemia and death may follow. In relation to management in the United States, all these genera are potential hazards to the multiplication of blackbuck. Profound anemia, weakness, rough hair coat and intermandibular edema are characteristic of this disease in all infected ruminants. The genera reported from blackbuck are ones also found in other ruminants, both wild and domestic.

The four genera are concentrated by intense use of areas such as is common in Texas on rangeland occupied by blackbuck. One way the blackbuck are infected is by ingesting the organisms at feeders and waterers where large numbers of individuals crowd into small areas. To control this requires setting out feed above ground level and constructing feeders so that animals cannot climb inside. However, reducing animal density is the only means of controlling the other avenue of infection. Regardless of whether feed is offered, blackbuck spend considerable time foraging among whatever green plants are sprouting. Therefore, the animals are exposed to contaminated plant material. To deal with this problem, domestic stock can be rotated and the pastures rested, but wild animals cannot be effectively rotated. Management plans should be aimed at reducing the probability of blackbuck ingesting infective larvae caused by fecal contamination of food and water, and the only practical method is to avoid high animal densities.

Another nematode which sucks blood and produces lesions similar to those made by the abomasal parasites previously named has also been reported in blackbuck. This is the sheep hookworm, *Bunostomum trigonocephalum,* which is found in the small intestine. As they appear in the feces the eggs of all of these parasite genera resemble each other. Demonstration of large numbers of trichostrongylid-type ova in the feces indicates that parasitic infection should be treated.

Coccidia

An additional infection which can lead to losses, particularly among young animals, is caused by coccidian *Eimeria* species (Fig. 10-1B). Coccidiosis in young blackbuck can be a severe disease producing dehydration, anemia and diarrhea. These coccidian parasites have produced mortality on the Edwards Plateau in Texas. Because these parasites are small and ubiquitous, coccidian infections are difficult to prevent. Probably the best treatment of affected animals is to reduce animal densities. Spreading the animals out over a large area seems to be the only feasible method of control. Since coccidia infections are also the result of fecal contamination and oral ingestion, the manager should attempt to maintain adequate separation between food and fecal material.

Ectoparasites

At times ectoparasites can be a troublesome problem. This is particularly true for hosts like blackbuck which are difficult to handle. Tick infestation can have severe consequences. The parasites debilitate the host by physically removing blood. Even more serious than their own impact on the host, however, is their function as vectors of disease, especially hemoprotozoan diseases. Some of these hemoprotozoan infections tend to be subclinical until a further stressor such as concomitant parasitism or malnutrition is added. One of the features which characterizes the Edwards Plateau where blackbuck have been so successful is a low external parasite load. Blackbuck there are remarkably free of external parasites. Of three blackbuck from two Hill Country ranches, Thornton *et al.* (1973a) found all three had the louse *Tricholipeurus parallelus* and two had ticks of the species *Amblyomma americanum* but none were heavily infested. A cursory inspection of 15 other Hill Country blackbuck turned up only 2 with ticks and another with lice (Spain pers. comm.).

Relationship with domestics

It is obvious from the list of parasites (Appendix G) that blackbuck share many species with domestic animals. In areas where blackbuck are exposed to, or pastured with, domestic stock, these animals constitute reservoirs of infection for each other. Control of parasites then becomes a problem of comprehensive pasture management rotation or of limiting the number of animals confined on a given acreage. Exotics can also bring new parasites with them. Neither *Camelostrongylus mentulatus* (Fig. 10-2A) nor *Trichostrongylus probolurus* (Fig. 10-2B) is indigenous to the United States, but both have been discovered in blackbuck on Texas rangeland. In laboratory tests, Thornton *et al.* (1973b) subsequently were able to infect sheep and goats, but not cattle, with larvae in blackbuck feces.

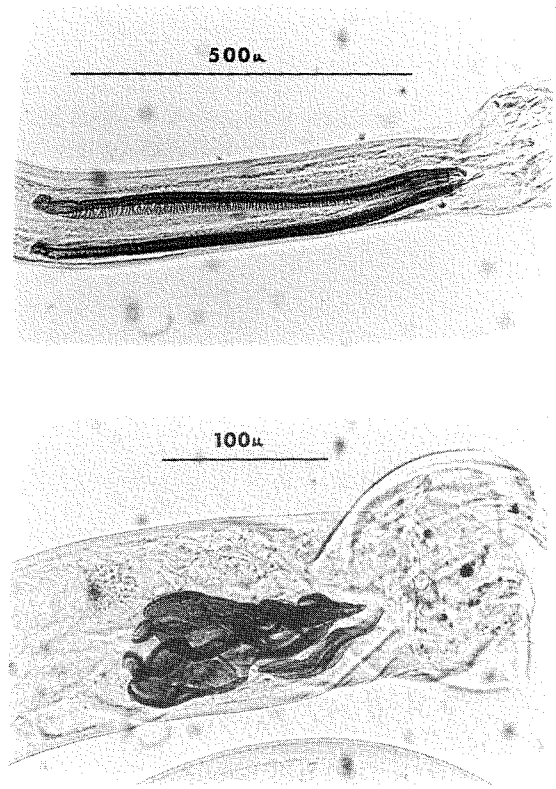


FIG. 10-2. Two parasite species not indigenous to the United States but recovered from blackbuck on Texas rangeland: (top) spicules of mature male **Camelostrongylus mentulatus** (100X) and (bottom) spicules and gubernaculum of mature male **Trichostrongylus proboturus** (250X).

Diseases

Few types of diseases other than the parasitic diseases indicated and one case of poisoning due to the metabolic products of the bacterium *Escherichi coli* getting into the bloodstream (Schmied 1973) have been documented for blackbuck. However, a major problem on

Texas rangeland is malnutrition during inclement winter weather. The blackbuck is a small ruminant, rather delicately constructed. Because of a relatively sparse haircoat and long extremities, it loses heat readily. Combined with the blackbuck's reluctance to take food to which it is unaccustomed, these are the contributing factors to what is probably the greatest blackbuck mortality in the United States.

If not fed regularly, blackbuck are generally hesitant to take supplemental feed offered during winter periods of stress. Consequently, blackbuck loose in pastures can seldom be saved when severe weather begins to produce mortality. Because of ruminant physiology, it takes time to convert the blackbuck's coarse rangeland forage into energy. In cold weather, the energy required to digest the vegetation is greater than the energy received from it; this results in a negative nitrogen balance in the animal and ultimately in death caused by "freezing" or malnutrition. Actually, the losses are a combination of the two.

On pastures where high energy forage is not available, losses associated with snow or freezing rain can amount to more than 90 percent of the population. To reduce this mortality a manager probably should feed his blackbuck a high energy diet in the fall to build them up with depot fat to convert into available energy during winter cold. This can only work, however, if the blackbuck have already learned to accept feed. Some ranches put out token amounts of feed once or twice a week during the summer when range conditions decline and then increase quantity and frequency in the fall. Nevertheless, the fact that malnutrition develops or that feeding is necessary indicates too many animals for the capacity of the range.

Injuries and abnormalities

Because of their light build and small size, blackbuck are highly susceptible to injuries. The most common problem is broken bones. In captivity this risk, plus the associated risk of tissue damage, increases as decreasing enclosure size raises the likelihood of a sudden fright sending the animals running against the fence. Lesser problems include overgrown hooves, tooth abnormalities and stereotyped behavior in confinement.

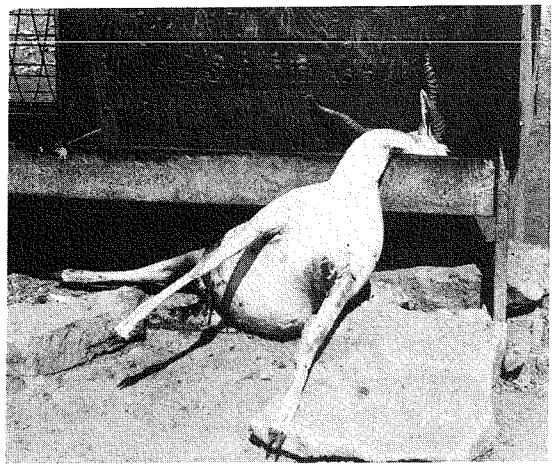


FIG. 10-3. Buck with a horn caught in feeder plywood. He broke his neck trying to get loose.

Broken bones and tissue damage

Blackbuck kept in small pens often traumatize themselves irreparably, particularly if they are captured as adults from large pastures. One of the most characteristic injuries, the lower lip split from the mandible, is caused by contact with mesh wire as a result of their extreme terror when first confined in small areas or when panicked by a sudden disturbance. The mandible itself may also be broken. Some of these injuries can be repaired, but broken necks or legs expected in any capture of blackbuck in open pastures usually mean that the animal dies or must be destroyed. Where feeders are used, they must be constructed so that a buck cannot catch a horn and break his neck in trying to escape (Fig. 10-3).

Leg injuries in wild blackbuck do not always mean death, even though a break may take a year or more to mend. Inspection of 41 skeletons from a population of 125 ± 15 blackbuck in a Texas pasture revealed three metatarsals with signs of past breaks (Fig. 10-4A, D and E). One young animal (class VII) also had a furrow in the outer surface of one metacarpal (Fig. 10-4A and I). Another young animal had a stout cylinder like a 3.5 mm (0.3 in) piece of pricklypear thorn embedded in the surface of the metacarpal, but the substance does not show on the radiograph (Fig. 10-4J). Previously, two other metatarsals with signs of healing breaks had been recovered from the same pasture, even though no special effort was then being made to search for such evidence

(Fig. 10-4B and C). Sample B was from a young animal (class X) dead less than 2 years before the bone was found (Fig. 10-4).

Specimens F and G are from a different pasture (Fig. 10-4). About a year before his death, this old male began walking with croup lowered. He often seemed reluctant to rise or move ahead or engage in sparring matches. Upon examination (class XXII at death), only the proximal ends of the metacarpals seemed abnormal. Specimens H and K, a normal metatarsal and metacarpal, respectively, are included for comparison (Fig. 10-4).

Limping does not necessarily denote a serious injury. Occasionally, a foreleg is caught briefly between the horns of an adversary if heads slip apart during a fight, and the affected buck may limp for an hour or more afterward. Frequently, limping indicates a stone lodged between the hooves. The inconvenience is only temporary, for the stone soon falls out.

Overgrown hooves

When they occur overgrown hooves pose a problem because they limit the movement of the animal. The affected individual is not only

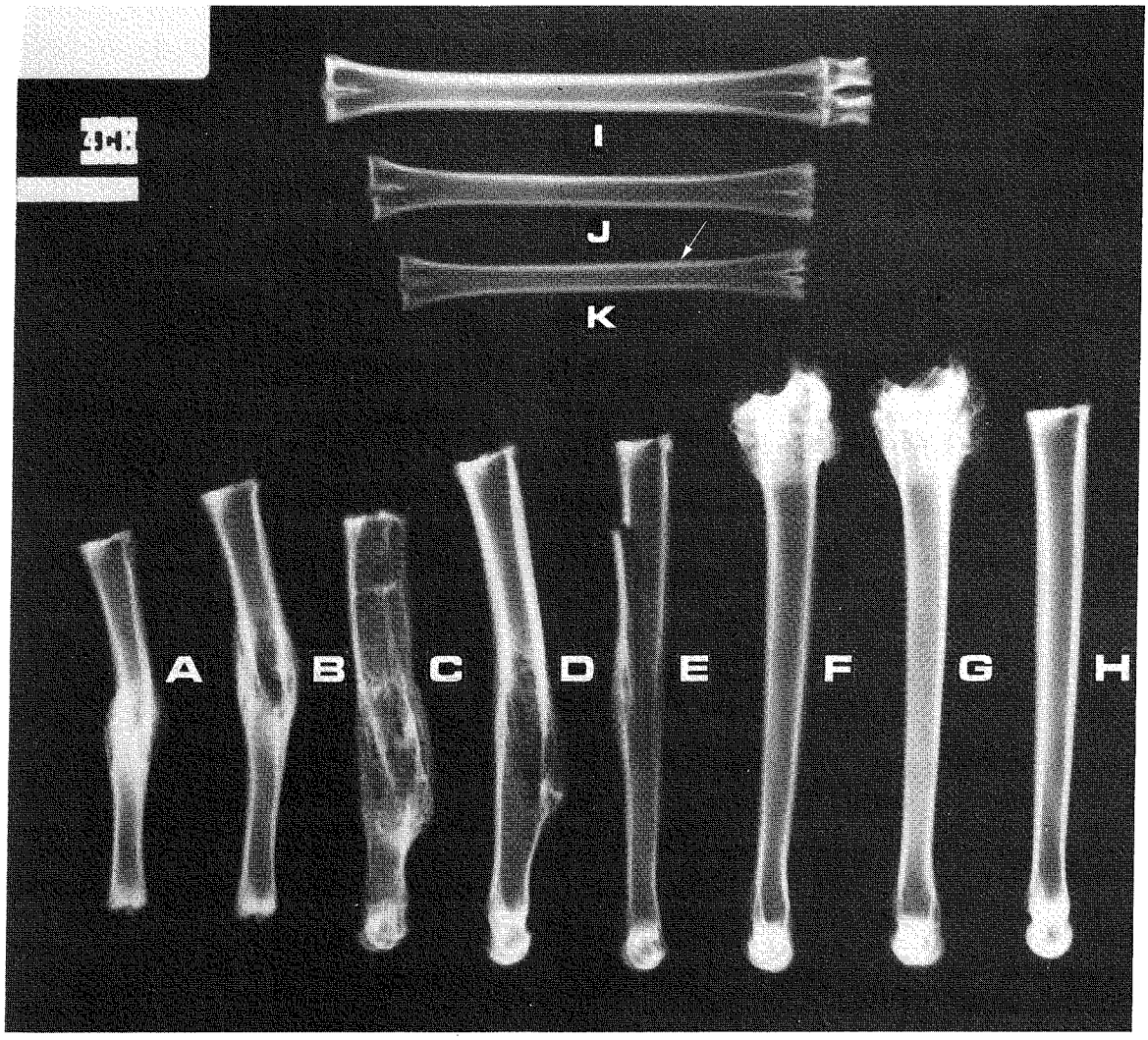


FIG. 10-4. Radiograph illustrating leg abnormalities observed in blackbuck that lived in unhunted Texas pastures: (A-E) five fractures with evidence of healing; (F and G) enlargement at the lower hock joints from a sixth individual; (H) normal metatarsal included for comparison; (I) normal metacarpal included for comparison; (J) metacarpal from a young animal that had a 3.5 mm cylindrical object embedded in the bone surface (not brought out by the x-ray process); and (K) metacarpal of a fawn that had a furrow (arrow) in this bone of its foreleg as well as having a previously broken hind leg (A).

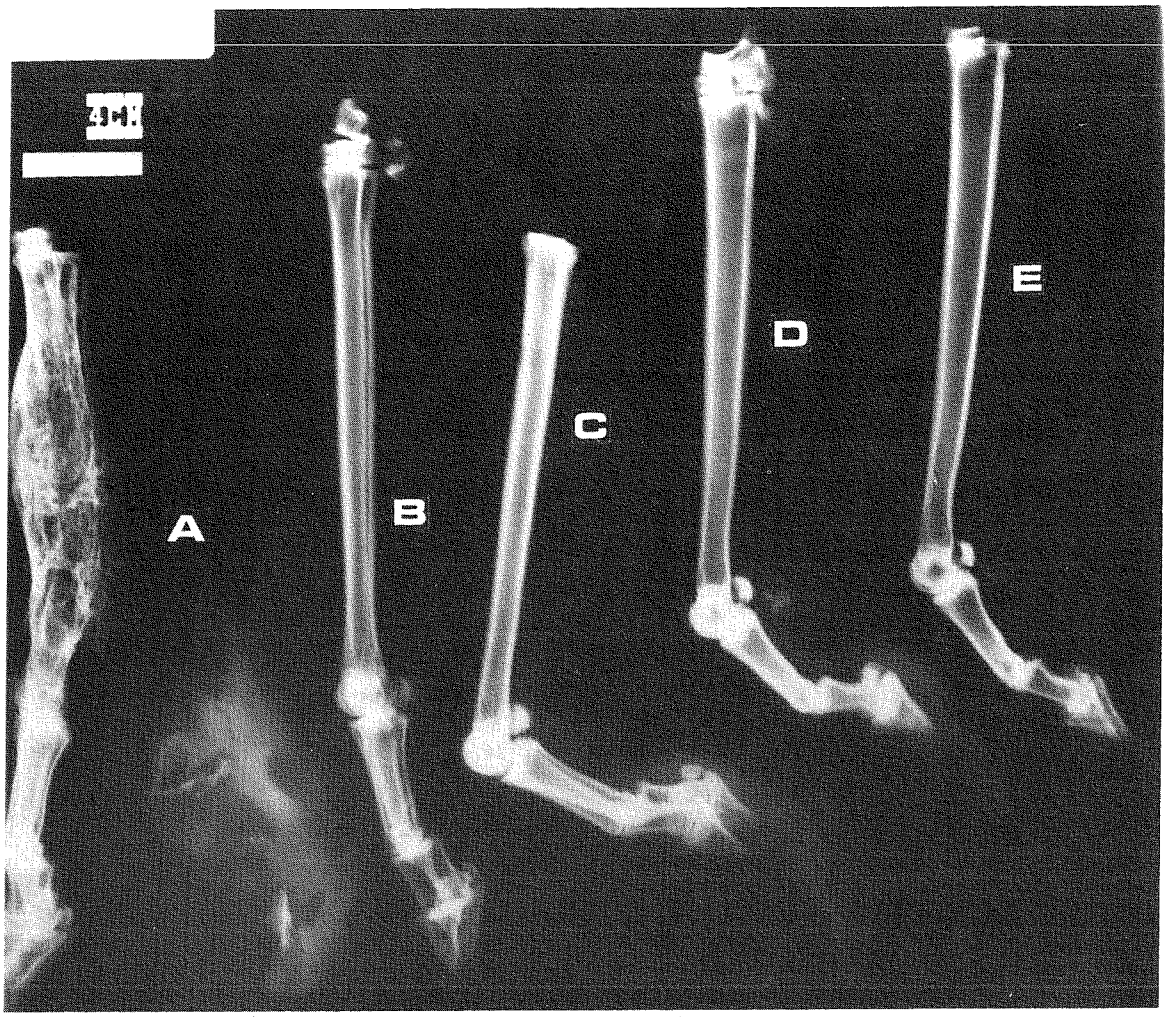


FIG. 10-5. Radiograph illustrating bone structure associated with hoof abnormalities observed in blackbuck that lived in unhunted Texas pastures: (A) foreleg with overgrown dew hoof containing bone that may have derived from splinters when metacarpal was broken — compare long bone in (A) with (A-E) in FIG. 10-4 — (B) normal foreleg from same animal as (A) and (E), (C) foreleg with hooves overgrown (dew hooves only slightly overgrown) but bone structure normal, (D) hind leg from same animal as (C) also showing hooves overgrown (dew hooves only slightly) and bone structure normal, (E) normal hind leg from same animal as (A) and (B).

unable to escape predators but also unable to avoid quick blows from conspecifics. If able to step aside promptly, all a blackbuck would ordinarily receive would be threatening gestures of a conspecific's head or horns. Even with long hooves, a very dominant individual can usually manage fairly well as long as it doesn't have to run.

Fig. 10-5 compares lower legs with normal and abnormal hoof development. In addition, specimen A shows osteomyelitis of the metacarpal similar to that of specimen C in Fig. 10-4. Both also show a shortening of the long bone (*cf.* foreleg Fig. 10-5A with normal foreleg Fig. 10-5B from the same animal). The horn overgrowth of the dew hoof in Fig. 10-5A is associated with abnormal boney tissue which may represent the sesamoid plus fragments from the indicated metacarpal break. Irritation from such fragments could have stimulated the proliferation of hoof material.

In specimens C and D (foreleg and hindleg, respectively, of the same buck; Fig. 10-5), the main hooves are overgrown, the forehooves even more than the hind. The dewhooves on all but the left foreleg are also conspicuously longer than normal. Nevertheless, bone structure appears normal (*cf.* with normal Fig. 10-5B fore and normal Fig. 10-5D hind). A captive animal can develop such hooves if kept on

too soft a surface or if insufficiently active to maintain healthy wear. Texas pasture blackbuck do not often show this abnormality, but in one pasture three males, including this one (Fig. 10-5C and D), were observed with long hooves. The other two had this condition, known as "snowshoes," only in front. With so many animals on the ranch, it seems doubtful that the supplemental corn given at some times of year could have caused founder which could, in turn, cause such an overgrowth. A greater possibility of founder existed for one penned buck with overgrown hooves (fore and hind). After capture, he was the dominant male and, consequently, the best-fed male in a group of six bucks receiving oats and hay.

If it can be caught safely, the affected blackbuck can be helped by hoof trimming. However, care must be taken not to cut into the quick or the resulting soreness will inhibit movement almost as much as long hooves do. Regrowth can be rapid, so repeat treatment may be necessary every few weeks. Since capture can be more hazardous than the effects of long hooves, pasture blackbuck are not caught for trimming.

Tooth and skull abnormalities

A number of pathological conditions were noted among 44 skulls out of a sample of skull material representing 501 blackbuck from Texas ranches. However, few of these abnormalities appear serious. Most involve misaligned teeth, enlarged sockets or minor peridontitis (bacterial invasion followed by bone looking spongy in texture) near tooth sockets. Even though only 10 percent of the sample represent old animals of classes XX and above, more than 34 percent of the specimens showing pathological conditions belong to this age group. The youngest class represented is VIII.

The cases of misaligned teeth include four immatures and nine fully adult animals as well as a class XX female and a class XXI male. The cases involving the incisors of young animals might have solved themselves with age. Because of the way the incisors form inside the alveoli (see radiograph series in Appendix B), I1 tends to emerge low and the rest of the incisors tend to emerge high. More frequently, maxillary molars are out of line, and in these skulls the sockets for the molars rotated frontward and outward are often enlarged. Typically, maxillary M1 is rotated a few degrees, throwing it noticeably out of line with maxillay Pm4, but sometimes all the molars on a side are affected, resulting in a zigzag rather than a comparatively smooth buccal contour to the tooth row. This abnormality is frequently bilateral.

One female skull (class IX) had an extreme change in tooth orientation (Fig. 10-6); the right madibular pm2 oriented across the jaw instead of parallel with it. The only similar instance located is reported from a female skull in the British Museum (Natural History); in this

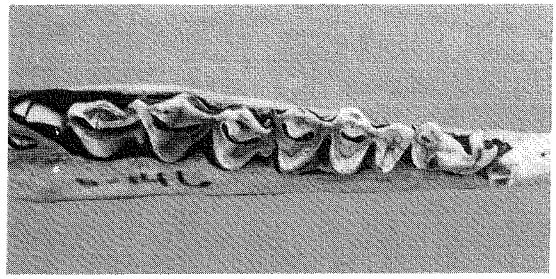


FIG. 10-6. Right mandibular pm2 of an immature female oriented across the jaw instead of parallel with it.

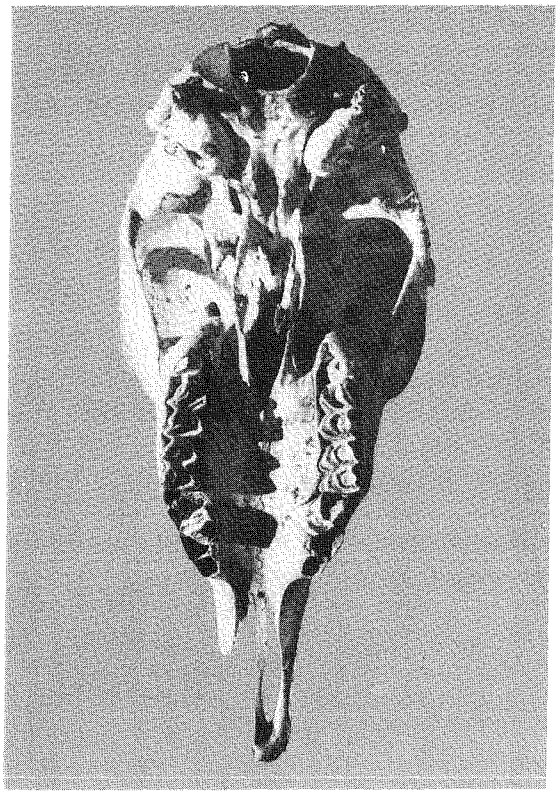


FIG. 10-7. Maxillary Pm4's crooked and lingual to tooth rows in an adult female.

skull (no. 74.463; 18 months old at death) the right maxillary Pm4 is 90° away from its expected position (this cannot reasonably be attributed to handling after death; Jewell *in litt.*).

In two Texas skulls, there seem to have been problems when the maxillary Pm4's erupted. They came through the bone just lingually to the tooth row in one doe (Fig. 10-7) and in another they seemed to have missed contact with the roots of the pm4's while erupting, for the pm4's are both present wedged between the Pm4's and the M1's toward the lingual side.

Localized periodontitis was noted in 10 cases. Often it surrounds one or more tooth sockets, and sometimes the edges of the socket seem to have eroded away or the jaw seems slightly enlarged there. Eight of the cases were in blackbuck of class XIX or older. These included one class XXII male in which the bones anterior to the orbits were affected and two class XXIV males in which the tips of the horn cores were affected.

A depression and flattening of the mandible by the most heavily worn mandibular teeth (usually by M1 and Pm4) is associated with old age. Cases of markedly uneven wear or teeth worn to the neck are rare in other age groups (only one case noted, class XVIII). Decayed teeth (four cases) and gaps between teeth (six cases) were not restricted to old individuals. Only twice was food seen wedged between teeth where there was no appreciable gap.

A class XVIII female was missing the left I2, but there was not even a socket for it and there was no gap between the tooth crowns. Although no duplicate teeth were found, a class XVII animal had attached at the posterior end of the madibular M3's what looked like a miniaturized replication of the secondary cusp. This animal and three others each had secondary cusps on the mandibular M3's that look as if they were set away from the adjacent tooth lobe farther than the average, such that the intervening space forms an infundibulum. Since all four of these animals are from class XVII, one might speculate that this may be a normal stage in the attrition of mandibular M3. However, the numerous other XVII skulls lack this construction.

Animals kept in small pens are apt to break incisors when they run against the fence in fright. Of six bucks in one pen, two were missing the right I1, and one of these males also lacked the left I2 and had a chipped I3.

Horn abnormalities

Horn abnormalities observed in blackbuck fall into six categories: grooved tips, broken horn, "compressed spiral," "extended spiral," "single curl" and castrated subject. Of four major blackbuck population centers under observation in Texas for a year or longer, each had one or more broken-horned individuals for at least part of the time, one had two individuals with a compressed spiral and one had approximately five bucks with grooved horn tips. In addition, the last population is reported to have had a buck with what was probably either an extended spiral or a single curl (Haggerton pers. comm.).

In a sample of 20 adult and subadult bucks from one Texas pasture, five had one or more grooves worn into at least one horn tip; no grooves showed below tip level. Fig. 10-8 shows one of the more extreme examples. The ends of both horns are worn off completely. It is commonly assumed in the Hill Country that these

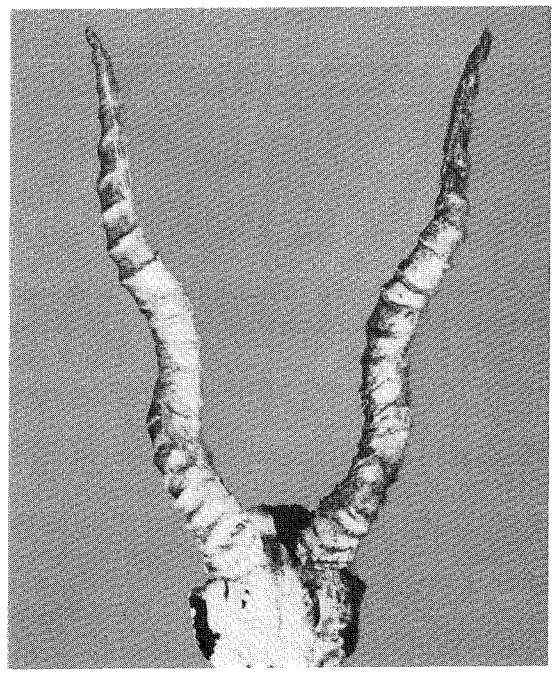


FIG. 10-8. Extreme case of grooved horn tips with deep and shallow grooves on both sides. Lateral orientation of grooves is characteristic.

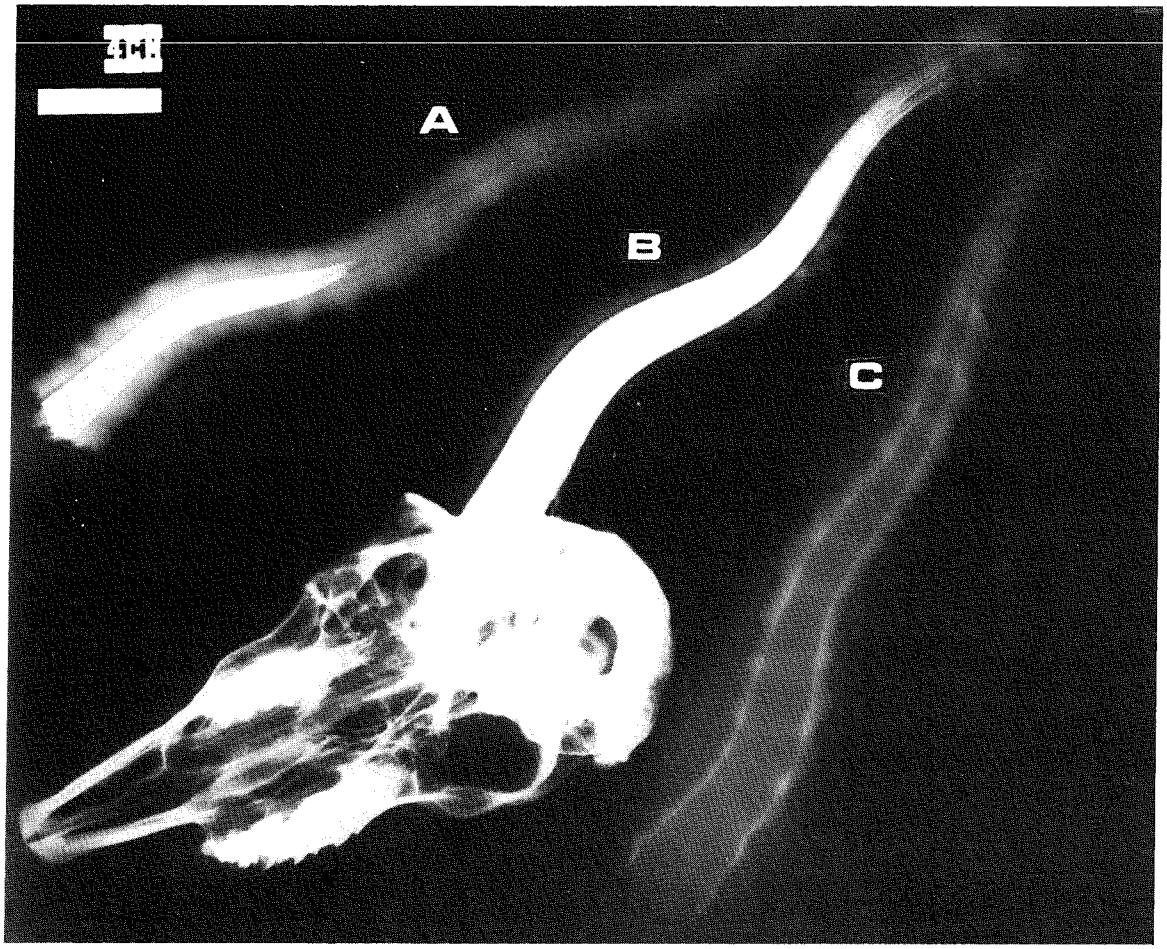


FIG. 10-9. The two major types of adult horn breaks: (A) A section of sheath and core break off together. (B) Adult after either type of damage heals. (C) A section of horn sheath splits off without the core.

grooves are the result of rubbing along fencing wire. Certainly bucks do thrash fences instead of bushes or other low vegetation as a form of redirected aggression when the real target is in a neighboring pasture. However, the fences are either square mesh or barbed wire so only short sections can be used without interruption. Whether the sideward flinging of the head when thrashing wire actually can start grooves has not been determined. To keep bucks from thrashing fences, blackbuck should not be kept in adjacent pastures and bucks in small pens should be provided with bushes or with sturdy substitutes made of flexible hose.

Ordinarily the incidence of horn damage is low except among older bucks of class XIX or greater. Most is caused by fighting or natural accidents. As grooves wear deeper, the affected horn tip becomes more likely to snap off or split. In Texas as well as in India a small number of breaks are also caused by unfortunate bullet strikes (White pers. comm.; Baldwin 1876).

Splitting usually affects the smooth upper portion of the horn tip and then is masked by subsequent wear, but breaks can occur at any level and they remain obvious. Bucks with as much as half a horn gone can still compete successfully because enough remains to keep the horns from slipping apart during a fight. Bucks with one or both horns broken near the bases have been observed holding territories, but it is uncertain whether such males can withstand persistent competition from normal males.

Adults show two main types of major breaks. In one, both sheath and core shear apart as one unit (Fig. 10-9A). In the other only the sheath splits away (Fig. 10-9C) and the exposed portion of the core then begins to deteri-

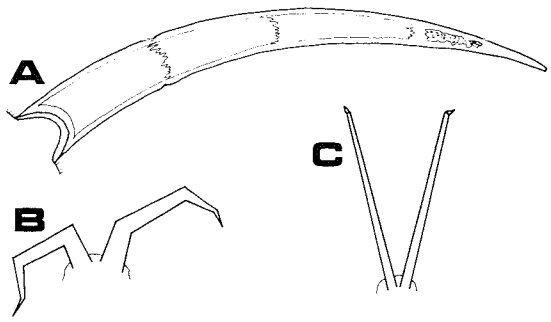


FIG. 10-10. Diagrammatic representation of frostbite damage: (A) Cross section of horn showing necrotic part of core near tip and necrotic band indicating winter freezing. Also note seam in sheath and extra horn layer that can wall off upper portion from growing base. (B) Result of fracture and rejoining at weak points. Note equality of levels but asymmetry of shape. (C) "Caps" when only tips show the effect of freezing in subadult and adult bucks.

orate. Thus, the final result of both is the same: a horn normal to the level of the break and then polished across its blunt end with the living core recessed about 2 cm (0.75 in) (Fig. 10-9B).

Another type of horn break is not solely the result of mechanical damage. Investigating the high incidence of spring and early summer breakage at the Henry Doorly Zoo, Simmons (1974) found that most of the lighter-horned antelope species show signs of avascular necrosis of the tissue inside the horn sheath if subjected to the extremes of Nebraska's winter climate. As explained by Simmons (1974), this frostbike damage takes several forms (Fig. 10-10). Breakage is common because affected horns are often attached only by the connection of sheath base with epidermis. Longitudinal section shows necrotic zones across the core corresponding to the winters the animal has survived. Occasionally whole sections of horn are empty of any core, and, when present, the bone above the more extensive necrotic areas is dead and dry. Horn tends to proliferate within the sheath at these necrotic areas and can even wall off the upper horn from its base completely. Therefore, breaks of frostbitten horns are not accompanied by the profuse bleeding characteristic when normal horns snap. Instead, hemorraging is minimal because a covering of horn is already forming over the live end of the core.

There are not necessarily any external signs of frostbite damage (Simmons 1974). One type of indication is a seam around each sheath at the level where growth was interrupted. These seams are extreme examples of the growth rings sometimes distinguishable where horn growth has slowed during the winter (Fig. 10-11). In other pairs of frostbitten horns equal lengths of the ends of the sheaths are skewed like caps at an abnormal angle (Simmons pers. comm.). This and the pronounced seams are the only apparently related phenomena recognized for blackbuck during the Texas study (Fig. 10-12). More exaggerated manifestations involve abrupt, asymetrical changes in angle at corresponding levels on each horn; the horns appear to have been pushed out of line at the weak

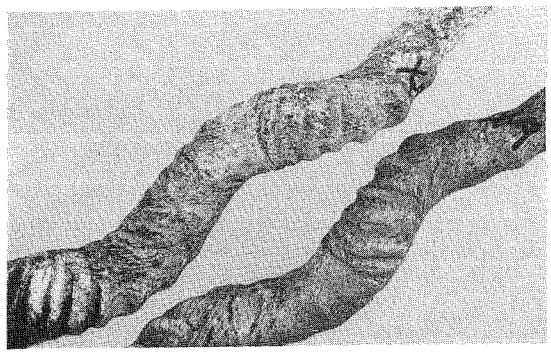


FIG. 10-11. Seam that developed on each horn at the base and moved upward during subsequent growth. Such seams can form when growth slows markedly during season of low vegetation quality.

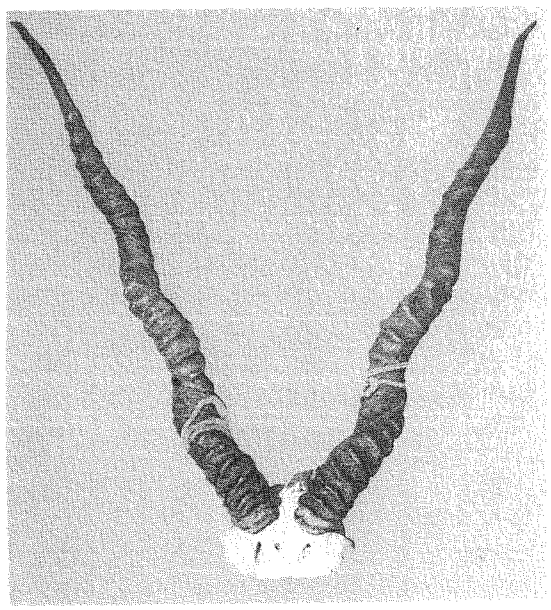


FIG. 10-12. "Caps" at the end of blackbuck horns where the tip axis is skewed out of line with the rest of the horn and a slight ring shows at the point of change.

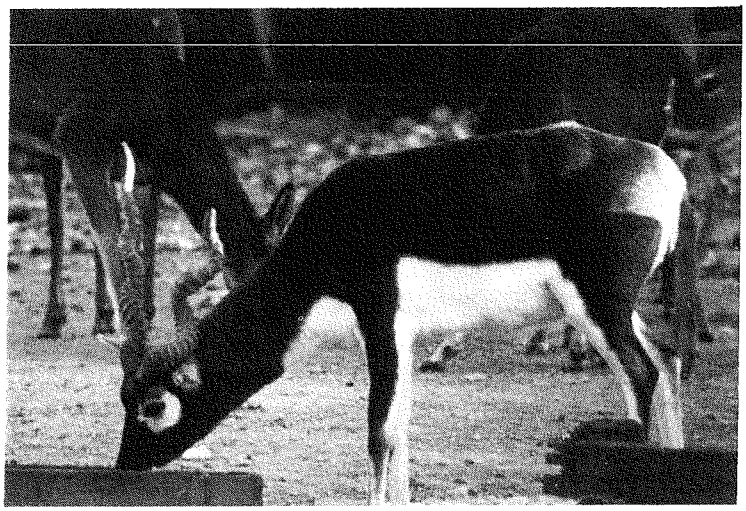


FIG. 10-13. Adult buck with a "compressed spiral" horn on one side. Horn sheath on that side had been lost at about 1 year of age.

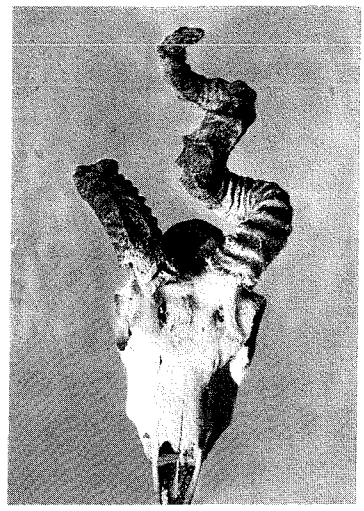


FIG. 10-14. Adult buck with a "compressed spiral" showing deviation from normal horn axis angle.

points but not entirely broken (Simmons pers. comm.).

The consequences of an immature buck breaking off a horn can differ strikingly from those for an adult. With its rapid growth rate, the immature male develops an abnormally shaped horn of the compressed spiral type. C. Ahrens (pers. comm.) observed that a buck who accidentally pulled off his whole left horn sheath when about a year old then grew a compressed spiral horn. This matched the normal horn in thickness, annulation and number of turns subsequently completed but had a blunt tip and a spiral more like a bed spring (Fig. 10-13).

Comparing this case plus the heads of five other compressed spiral males from Texas pastures with a history given by Schmied (1973) for a buck that knocked off one horn at the base as a 13-month youngster indicates two generalizations. First, the end result is basically the same whether just sheath or core and sheath together is broken. Second, the angle of the horn axis may be altered if the core is broken in the original accident (Fig. 10-14).

The Texas specimens also illustrate that such animals have an even chance of breaking the abnormal horn after maturity. The rigid coils probably catch and hold more easily than the wavy spear of the normal shape. The similarity of an addax observed in a Texas pasture with a broken compressed spiral suggests that the same mechanism operating in blackbuck may apply more generally.

Three other horn conditions are even less common. The extended spiral of a 2-year-old Texas buck (Fig. 10-15) is reminiscent of that shown for a dark adult buck shot in India some 50 years ago (Fig. 10-16). In both the horn spirals much less than normal per unit length and is flattened enough to create a keeled effect at the tip. Each animal also shows a conspicuous shift of the horn axis. A Texas adult that shows traces of flattening lacks the other features. Since the 2-year old's horn development was abnormal from the beginning and no horn injuries were observed, this anomalous horn form may be genetic in origin.

Unless correlated with hormone imbalance as suspected in certain blackbuck reported as horned females, the cause of single curl horns is unknown. These horns sweep back in an asymmetrical, sheep-like curve (Fig. 10-17). Only one authenticated and two possible cases of single curl have been reported in Texas within the past 20 years. An Indian buck with a single curl horn on one side raised speculation that the testis on the affected side may have been injured (Jerdon 1874). The conjecture probably has its basis in the tradition, handed down by generations of hunters and gamekeepers, that injury to one testis or one leg of a deer results in unilateral antler malformation. By checking the

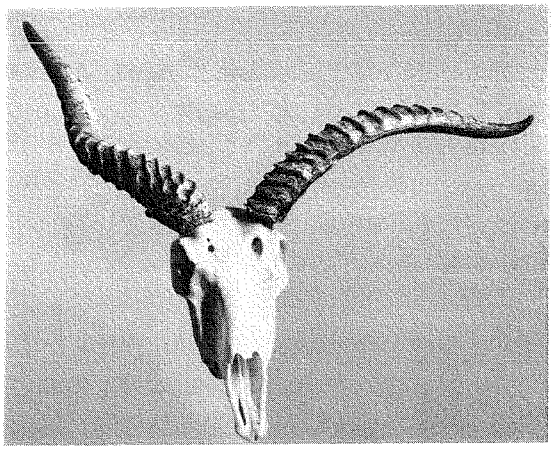


FIG. 10-15. "Extended spiral" of a 2-year-old Texas buck.

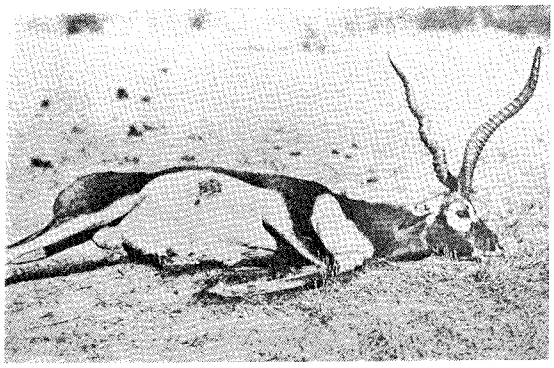


FIG. 10-16. "Extended spiral" of adult buck shot in India. (Photograph from Singh 1928, courtesy Bombay Natural History Society.)

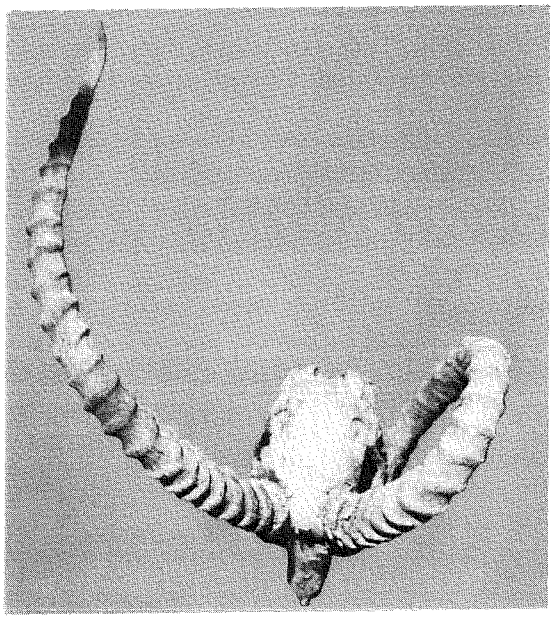


FIG. 10-17. "Single curl" horn form in an adult.

histories of fallow deer with one abnormal antler, Gaskoin (1856) could not support this theory; Flower (1894) could partially, although his evidence was contradictory as to whether the effect of removing one testis is contralateral. Nevertheless, there is experimental support. Contralateral antler malformation followed unilateral castration in one of two sika bucks (Penrose 1924). In white-tailed deer, four bucks showed a contralateral effect after amputation of one hind leg and an abnormal antler developed on the same side as a broken scapula in another buck (Marburger *et al.* 1972).

Thus far, all the horns discussed have looked robust in character with pronounced rings at the expected intervals. Castrated bucks, however, grow shorter or thinner horns with weak or irregular annulation. One adult (see Fig. 7-4) had horns of about 20 cm (8 in) shaped like those of a yearling (Krumbiegel 1955). In contrast, the London Zoo adult shown in Fig. 10-18 has one horn approximating the single curl form in direction and length and the other horn broken off (Bennett 1836, Bennett *in* White 1837). Since the remaining horn looked normal until the level of what would indicate the first spiral in a normal buck, Bennett (1836) assumes the male was castrated at this stage; after this point, annulation fades away and the horn fails to increase in diameter. Therefore, it is hypothesized that castrates, prohibited the

FIG. 10-18. Adult castrate in London Zoo. Other horn had broken off. (Figure from White 1837.)

usual amount of testosterone, develop abnormal horns due to hormone imbalance.

"Horned females"

Normally blackbuck females are hornless, but occasionally individuals in Texas as well as in India do develop horns. This should be no surprise, since a survey of species in the blackbuck's subfamily, Antilopinae, shows wide variation in this respect between and even within species. The blackbuck singled out as horned females are characterized by combinations of the attributes listed for castrated bucks and for single curl bucks: horns which sweep back from the head with only a suggestion, at most, of twisting near the tip; annulation often indistinct and irregular or absent; diameter tending to be noticeably small, even at the base; and asymetry. Although the figure by Stebbing (1911) shows medium-diameter horns with normal annulation arcing upward at different angles with only one turning downward significantly, the most common comparison suggested by Indian examples is that the horns curl like those of sheep (Fig. 10-19).

References to horned females in India are scattered through the literature. Jerdon (1874) knew of three. Blanford (1888-91) saw a horned female near Nágpur. Hume bequeathed the skull of one (Fig. 10-19) to the British Museum (Natural History) (skull no. 1912.10.31.26; Lydekker 1913). And G. (1909) was accused of shooting the tame horned female that lived in an Indian village when he reported bagging a doe with 47 cm (18.5 in) semi-circular horns. Unlike the others, including the village pet, G.'s doe was black (G. verified by the editor of *The Asian,* 1909)!

The resemblance of these Indian examples to castrated males and single curl males throws doubt on the true sex of these animals. Most fortunately, reproductive tracts from two of the three, or possibly four, Texas horned females were made available for anlaysis after the natural deaths of the animals. Combined with one German record (Krumbiegel 1955, Fig. 757) these reveal that horned females can be normal females, sterile females or hermaphrodites. A specimen not examined closely could also be a single curl male. The possible fourth Texas example of a horned female may well have been a single curl male instead.

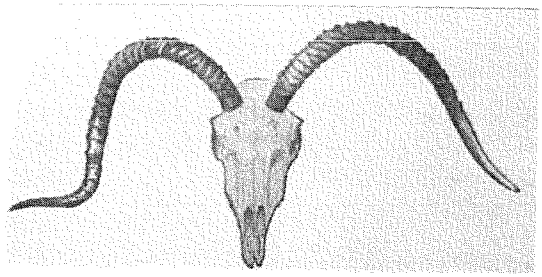


FIG. 10-19. Skull of a class XIX horned female shot by A. O. Hume in India. (Figure from Sclater and Thomas 1897-98.)

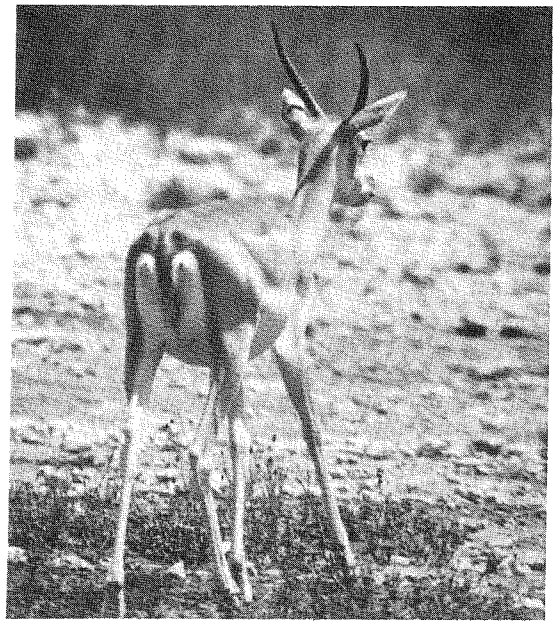


FIG. 10-20. Sterile class XVII horned female in Texas pasture. Note asymmetry of horns and lack of twisting.

The similarity in horn structure of the Hume skull (Fig. 10-19) and the three Texas horned females observed during life (Figs. 10-20 and 10-21) to that of the London castrate (Fig. 10-18) suggests that in none is the hormonal state adequate for typical species horn development. Although somewhat ambivalent, the results of the ethological data indicate stronger female tendencies and less aggressive behavior than shown by adult males (Mungall *et al.* in press).

Aberrant behavior

Stereotyped behavior of a pathological sort is common in zoo animals. Blackbuck are no exception. A doe kept alone in an enclosure of about 0.4 ha (1 ac) continually travelled the

same route along an approximately 20 m (22 yd) row of bushes near the central part of her pen (Schmied 1973). After capture, using a dart loaded with muscle relaxant, and subsequent transfer to a 2.3 ha (5.7 ac) area with an established blackbuck herd, this female returned to normal (Schmied 1973).

Often more worrisome, but less serious, are cases in which a female repeatedly rejects her fawn. A primiparous doe sometimes does not develop normal maternal responses; her offspring may never develop the sucking reflex and it will then die (see Chapter 6). Pluripares, however, may merely be temporarily sore from the birth or disturbed by the presence of observers. When continually refused by the mother, success for the young depends upon its aggressive persistence in staying with its dam during the active periods and striving to nurse.

Cold, ice and drowning

Aside from the complications already discussed in relation to malnutrition and broken horns, low temperatures can create other problems. Animals exposed to severe winter weather sometimes acquire short, club-shaped ears because the blood vessels contract with the cold to such an extent that the tissues of the ear tips die (Fig. 10-22).

Although blackbuck in a herd maintained on dry feed during the winter may eat snow with impunity, the results of ingesting other frozen items can be drastic. Three sudden deaths in Austria were attributed to eating frozen food. (Schmied 1973).

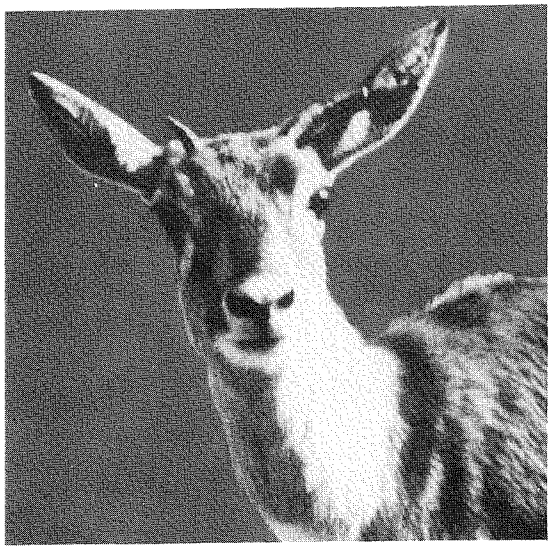


FIG. 10-21. "Horned female" adult in a Texas pasture showing the same horn form as an adult with a normal reproductive tract collected on a neighboring ranch.

This same Austrian herd lost five blackbuck to drowning: one in summer and four in winter (Schmied 1973). Expanses of deep water can be a hazard at any time, but especially when covered with ice. Unlike roe deer who frequently encounter ice in their native habitat and who tread warily on ice and avoid it if unstable, blackbuck do not hesitate unless there is open water along the shore (Schmied 1973). Most Texas blackbuck probably have no opportunity to get into deep water, but at least one ranch manager pulled a buck out of a lake, only to find him there dead later (C. Ahrens pers. comm.).

Summary

Parasites and malnutrition pose a potential threat to the successful management of blackbuck antelope. When maintained on an adequate diet, however, blackbuck are hardy individuals even under open range conditions. Relatively few diseases are reported to affect this species. If this reflects a degree of hardiness when exposed to diseases of domestic animals, then the blackbuck is one of the hardier of the exotic species popular in Texas, as long as the results of winter cold in open pasture situations are excluded. Winterkills due to cold weather and inadequate energy in the diet are probably one of the major sources of mortality among pasture blackbuck. On exotics ranches in the United States blackbuck begin to die from exposure and inadequate nutrition long before the other species. This is a consequence of their relatively delicate anatomical construction and small size which allow them to lose heat more rapidly than the other species. To date, there have been practically no disease studies involving blackbuck. Therefore, vaccination schedules cannot be advised. Parasite problems, when encountered, are generally attacked by management procedures for prevention and control in the whole population rather than by procedures involving the handling of individual animals. This is because of the difficulty of capture and the risk of trauma during capture or treatment.

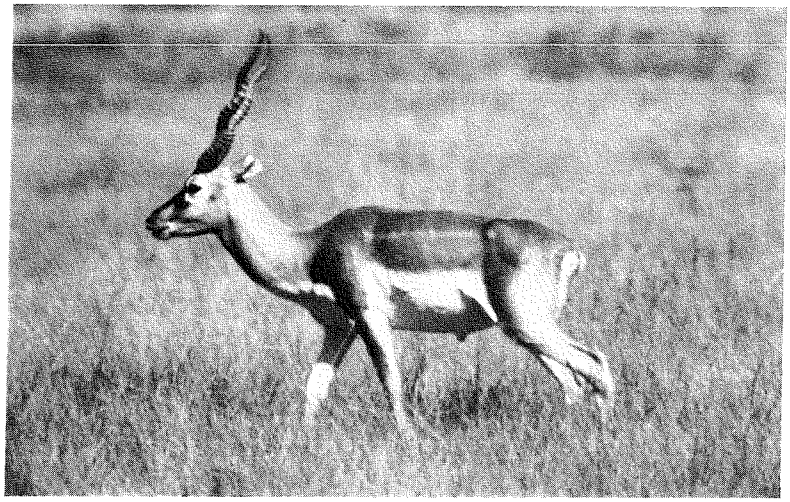


FIG. 10-22. Buck showing typical club shaped ears resulting from frostbite.

Although magnified in small enclosures, problems involving broken bones and tissue damage still exist for blackbuck loose in pastures. Broken legs, particularly the long bone of the hind leg, appear to be the main problem of this type. Some individuals are able to recover without treatment. Whether overgrown hooves in pasture blackbuck can be attributed to founder is unclear. In captivity, overeating by a dominant animal may contribute to this problem.

Of 501 skull records, 9 percent showed tooth or skull abnormalities. Most of these were misaligned teeth, enlarged sockets or bone with localized spongy texture associated with minor periodontitis. Few of the abnormalities appeared serious. Old blackbuck of at least class XX were affected 24 percent more often than their frequency within the total sample would suggest.

The six categories of horn abnormalities observed in blackbuck are grooved tips, broken horn, "compressed spiral," "extended spiral," "single curl" and castrated subject. Splits and breaks are more common among older animals of at least class XIX. Breaks in young, rapidly-growing males lead to development of a compressed spiral horn on the injured side while breaks in adult, slow-growing males do not. All feeders should be designed so that bucks cannot catch their horns. Not keeping blackbuck in adjacent pastures and giving penned males bushes or synthetic substitutes to thrash may help prevent horn grooves which can promote broken horn tips. Castrated males grow short or thin horns with weak or irregular rings. Other abnormalities may be genetic, and the affected individuals should be removed if such genes are not wanted in a breeding program.

Once every few years in every major concentration of blackbuck there appears a "horned female." These animals show a combination of traits found in castrated and single curl males and may be confused with them if not examined closely. Reproductive tract analysis reveals that true horned females may be either normal females, sterile females or hermaphrodites. Therefore they are more likely to increase curiosity value rather than reproductive potential in a population.

As Schmied (1973) found, even long-established stereotyped behavior of a blackbuck kept alone in a small enclosure can be corrected. Transferring the individual to a large enclosure in a complex environment already inhabited by blackbuck can bring a return to normal behavior.

Primiparous females are sometimes poor mothers. Rejection of a fawn by a pluriparous mother is usually only temporary.

In extreme cold, the ears of blackbuck are subject to frostbite. Blackbuck may eat snow with impunity, but ingesting frozen food can cause death. Deep water poses a drowning hazard, especially when covered with ice. Blackbuck walk heedlessly onto the ice and may fall through.

(Richard M. Robinson, Jack E. Thornton and Thomas J. Galvin contributed to Chapter 10.)

11

BLACKBUCK AND THE LAW

☐ Anyone who owns or manages blackbuck antelope is affected by a number of laws and regulations. Since lawmaking is a continuing process, new modifications and new regulations are apt to appear at any time.

India

In India, the legal status of the blackbuck is comparatively simple because it is a native species. The Indian Board for Wild Life, created in 1952 to advise in conservation matters, includes the blackbuck among 36 animals listed as in need of protection (Sarkar 1975). However, the authority over wildlife rests with the states rather than with the central government, so action on measures like the Wild Life Protection Act banning the killing of 61 endangered species tends to be uncoordinated (Gee 1969, Putman 1976). Another problem is conflicting interests. For example, Gujarat State has entirely outlawed the shooting of blackbuck, but the integrity of two large reserves committed to their protection is threated by the Gujarat Agricultural Lands Act of 1960 which limits land holdings to 29 ha (72 ac) or less (Oza 1977).

United States

Since blackbuck are not native to the United States, they come under laws affecting exotics as well as laws affecting certain types of animals in general. Some of the laws regulate importation. Veterinarians assigned to the Bureau of Animal Industry created by Congress in 1884 enforce quarantine laws designed to prevent entry of foreign pathogens when their hosts are admitted (Smith 1968). In a special effort against introduction of foot-and-mouth disease and rinderpest, governing statutes of the Department of Agriculture prohibit importation of wild ruminants, such as blackbuck, or wild

swine except to certain approved zoos where they must remain for the rest of their lives (Smith 1968). Only their offspring may be removed from these areas. Thus, the brood stock for blackbuck and other exotic ungulate populations on Texas ranchlands came from zoos. (For more on origins, see Chapter 1).

When Congress passed its first federal law concerned primarily with game species, the Lacey Act of 1900, at least two major U.S. zoos had already acquired blackbuck antelope. Concerned over damage from introductions such as rabbits to Australia, mongooses to Hawaii and starlings to the United States, the legislators sought to prevent establishment of exotics in the U.S. by instituting a permit system to keep out likely colonizers. Previously there had been no means of monitoring importations of animals and no record-keeping authority (Banks 1976). Initially hardly any wild mammals, birds or reptiles could enter without a permit, but changes a few months later exempted 30 types of mammals, 3 groups of birds and all types of reptiles (Banks 1976). The changes also let persons entering the country bring in up to five animals without a permit. A declaration at U.S. customs was required for every animal brought in without a permit. Beginning in 1966, all live fish and wildlife entering the United States had to be declared. The present procedure is to file the U.S. Fish and Wildlife Service Form 3-177, "Declaration for the Importation of Wildlife," with the District Director of Customs at the port of entry where the animal is cleared by customs (Banks 1976).

After more than a year of announcements and meetings, further changes published in the *Federal Register* of December 20, 1973, have been held in abeyance until either more enforceable regulations or new legislation can be offered (Anon. 1975b). The original form of the Lacey Act had banned importation of a few injurious species — mongooses, fruit bats, starlings and the English or European house sparrow — and had authorized the Secretary of Agriculture to add others to the list if they might endanger agriculture or horticulture. Under this authority the U.S. Department of the Interior proposed in 1973 to extend the list of "injurious wildlife" by exclusion to cover all nonindigenous wildlife species except the golden hamster, jird (gerbil), guinea pig, laboratory strains of the brown or Norway rat and laboratory strains of the house mouse. Species other than these five could be imported only by permit granted for scientific, educational, medical, or zoological purposes. In addition, no progeny of any of the "injurious" animals imported under permit could have changed hands without a permit. As stressed in a 1976 letter from the Department of the Interior deputy assistant secretary for fish, wildlife and parks, animals already in the United States and their offspring would not be affected (Bohlen *in* Anon. 1976). New regulations are still expected.

As passed in 1966, the Animal Welfare Act applied only to dogs, cats, hamsters, guinea pigs, rabbits and monkeys. The amended version of 1970 covers not only these, but also any other warm-blooded animal that the Secretary of Agriculture determines is used or intended for exhibition, for experimentation or as a pet. Even if their animals are not put on exhibition, used for research or kept as pets, those owning exotics like blackbuck may still fall under the provisions of this act if involved in commerce with such interests. The regulations set standards for adequate housing, food, water, sanitation, handling, shelter, ventilation and medical care. Those licensed under the act must keep records on their animals and must allow inspection at any reasonable time.

Although not directly affected yet, the blackbuck could become subject to endangered species regulations if its decline in India continues. (For a discussion of this decline, see Chapter 1.) The Endangered Species Act of 1973 broadened the scope of the Endangered Species Act of 1969 to include individuals already in the United States and their offspring. In addition, it prohibits any commercial activity in endangered species. Further species can be placed on the endangered list at any time by publication in the *Federal Register*. Regulation changes proposed by the Department of the Interior in 1975 finally separated imported specimens and captive, self-sustaining populations into separate categories and extended the range of activities allowed with the latter group. As for threatened species, permits for animals in these self-sustaining populations would be available for ". . . Scientific purposes, or the enhancement of propagation or survival; or Ec-

onomic hardship; or Zoological exhibition; or Educational purposes; or Management by State conservation agencies; or Special purposes consistent with the purposes of the Act." (Anon. 1975a, p. 28719).

In 1976, the Oklahoma City Zoo reported a "major breakthrough" when a private breeder was issued an Endangered Species permit to purchase a gaur from the zoo for experimental hybridization with domestic cattle. This permit was the first issued under the Endangered Species Act of 1973 to a nonpublic zoo for an individual of an endangered species from a self-sustaining population. (Anon. 1976).

Texas

In 1965, the Texas legislature found it necessary to rewrite the official definition of "game animal" because private ownership of exotics had become so common in the state. Some foreign species like the blackbuck had already lived on Texas rangelands for more than 30 years (Jackson 1964). The new version clarified the status of exotics by listing the familiar native mammals of Texas and stating, ". . . no species of any of these animals or any other animals is classified as a game animal if it is not indigenous to the state or any part of the state." (Anon. 1974, p. 975). Therefore, exotics are lodged in the same legal category as domestic livestock. Exceptions require special state legislation. Aoudad sheep, natives of northern Africa, were changed to "game animal" status in eight Texas counties (P.C. Art. 892); Bexar County placed its Asian axis deer in the same regulatory category as native deer (V.A.P.C. Art. 978 j-1); Kendall County had hunting and killing of its axis deer made unlawful outside of property under deer-proof fencing (Acts 59th Legis., Ch. 426). Blackbuck antelope have not established free-ranging populations, so their status has not been challenged.

Summary

The legal status of blackbuck in India is comparatively simple because this animal is a native species. The Indian Board for Wild Life has included blackbuck in the list of animals needing protection, but the promulgation of protective measures in the different parts of the country has varied widely, since wildlife is a state, rather than a federal, subject in India. Conflicting laws regulating land use are also a problem.

Since blackbuck are not native to the United States, the scope of applicable laws is broadened to include statutes dealing with importation of, and traffic in, foreign animals. Anyone dealing in exotics has a multitude of regulations to observe. It is his responsibility to be aware of the most up-to-date versions of these laws. This task is complicated by the number of separate organizations with jurisdiction in various circumstances. Among the foremost in the federal sphere are the Department of Agriculture, the Department of the Interior, the Department of Commerce and the Department of the Treasury. Much of the involvement of these agencies is effected through associated branches, such as the U.S. Fish and Wildlife Service and the U.S. Customs Service.

New provisions of three federal laws which have been the center of attention recently concern "injurious wildlife" restrictions under the Lacey Act (Department of the Interior), standards for housing and handling under the Animal Welfare Act (Department of Agriculture) and permit categories under the Endangered Species Act (Department of the Interior).

Because Texas laws do not recognize exotics as a separate category, blackbuck in Texas fall into the same legal category as domestic livestock. Exceptions require special state legislation. Thus far, only aoudad sheep and axis deer have established free-ranging populations large enough for some counties to have "game animal" status for these species.

(Chares W. Ramsey contributed to Chapter 11.)

12

MANAGEMENT

☐ In terms of both popularity and numbers, the Indian blackbuck antelope has a success record in Texas matched only by the axis deer. In 1939 and the early 1940's, Richard Friedrich released animals of several exotic species, including blackbuck antelope, on his Bear Creek Ranch which was later bought by Capt. Eddie Rickenbacker (Schreiner 1968). At that time, no one dreamed they would become the brood stock for a new facet of the hunting industry (M. Sikes pers. comm.). Natural increase plus new releases have resulted in 7,339 blackbuck in Texas by the 1974 census (Harmel 1975). (For a fuller discussion of introductions and numbers, see Chapter 1.) Eighty-one percent of these blackbuck share rangeland on the Edwards Plateau (Harmel 1975) where hunting now ranks with ranching in major economic importance. Thus, concern has developed over possible areas of conflict between imported and native game or livestock. At the same time, owners need information on which to base management decisions.

Habitat

The vagaries which determined early introduction sites plus the conditions encountered have resulted in only 3 of the 10 ecological regions in Texas having more than 1 percent of the Texas blackbuck population: 6 percent in the Crosstimbers and Prairies, 11 percent in the South Texas Plains and 81 percent on the Edwards Plateau (Harmel 1975). To the north and west of the Edwards Plateau, snow and cold winter winds sweeping down from Canada render it impossible to keep blackbuck under range conditions. Here blackbuck must be provided shelter and food during the winter, such as they are given in zoos. West and south of the Edwards Plateau, high predator pressure can negate stocking efforts. Fawns are particularly vulner-

able, but coyotes corner even fully grown antelope against fences and kill them (Robinson pers. comm.); only large populations can sustain themselves in spite of the heavy fawn mortality. Predation is not such a serious threat to blackbuck on the Edwards Plateau only because a long history of predator control to protect livestock operations there has kept predator densities low. Along the Gulf coast, both cattle and the native white-tailed deer carry giant liver flukes *(Fascioloides magna),* a parasite that decimates blackbuck herds brought into this region (Robinson pers. comm.). In humid eastern Texas, various stomach worms infect blackbuck and prevent rapid population expansion (Robinson pers. comm.). (For more information on parasites, see Chapter 10.)

Blackbuck are xeric grazers favoring open plains and lightly wooded areas (Dharmakumarsinhji 1967, Berwick 1974, Cary 1976a). They fail to thrive in wet environments, thick woods or rugged mountains. Heat and drought are tolerable, but cold rain, snowcover or ice can cause numerous deaths if prolonged. These restrictions should be considered when evaluating blackbuck habitat. (See Chapters 2 and 10.) No indication of adaptation of reproductive cycles to North American seasonal changes has been found. The synchronizing effect of mortality during particularly severe winters is only temporary. (See Chapter 6.)

Demands on water supplies in ponds and troughs are light, and trips to water are conspicuous only during hot, dry periods. The rest of the time, dew and occasional rain pools supply much of the blackbuck's water. Twenty-four-hour grazing patterns maximize intake of moisture with plant matter. The behavioral responses to heat and wind mentioned in Chapter 4 aid in preventing undue evaporation. In addition, heat loading, as found in certain gazelles (Taylor 1972), very possibly helps conserve water.

Oak motts or any brush that can provide shelter, visibility and cover soft enough to lie on are needed for the behavioral responses which act to maintain internal homeostasis. Blackbuck frequently retreat into brush when surprised in an opening or when relenlessly pursued in the open.

Although enclosures of 1.2 ha (3 ac) and less suffice for reproduction, full behavioral expression for a group of all sex, age and social categories requires closer to 40.5 ha (100 ac). Most of the pasture area should be flat to gently rolling grassland, but scattered or elongate brush areas are also important. Small pastures may be dominated by a single buck if there is only one opening. Such domination proves impossible in large pastures of 200 ha (500 ac) or more. Large pastures with interconnecting openings allow free movement of female herds as well as allowing large numbers of territories held by mature males.

In considering opening size, it should be remembered that blackbuck territories approach 1 ha (2.5 ac) and 20 ha (49.4 ac) as lower and upper limits with approximately 4 ha (10 ac) as an average. Because territorial males without territorial neighbors begin to wander, openings large enough for more than one territory are preferable. Also, bachelor males need space in the open grass areas. Typically, bachelors spend at least part of their time within sight of the territories. This speeds replacement of territorial bucks who are no longer tenaciously defending their borders.

Competition for food

Blackbuck are predominantly grazers (Dharmakumarsinhji 1967, Berwick 1974, Cary 1976a) but, if available, browse such as live oak leaves supplies a high proportion of summer forage (Cary 1976a). (See Chapter 9.) Thus, blackbuck are potentially in competition with domestic and exotic grazers. However, almost all deer, including native whitetails, out-compete blackbuck for browse in the form of tree leaves because blackbuck are shorter than the deer and rarely ever compensate by rearing on their hind legs. Therefore, only range with enough grass to support all grazers should be considered for stocking blackbuck. Temple (1976) suggests six blackbuck be taken as equivalent to one animal unit. Numbers should be adjusted to changes so that overgrazing will not result.

A few ranches use the same pastures for both domestic livestock and wildlife species. However, guidelines for optimum stocking combinations have not been determined. Because of differences in food habits, animal unit equivalents do not give complete information for such situations. Furthermore, domestics

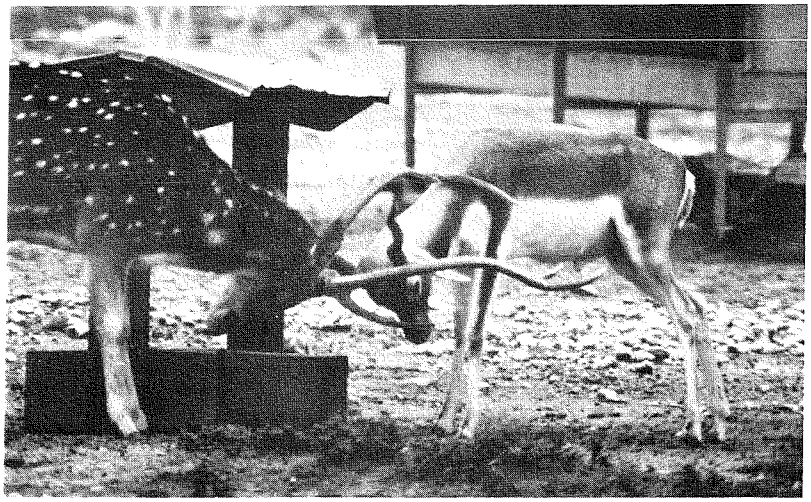


FIG. 12-1. Blackbuck (right) and axis male engaging after both tried to use the same feeder at the same time. Blackbuck and axis males, but not females, are close in biological rank.

can be rotated from pasture to pasture, whereas wild animals cannot. To avoid increased disturbance which can displace blackbuck females from favored birth sites, livestock should not be permitted during fawning peaks in pastures with high blackbuck densities.

Blackbuck graze with other species more readily than they share resting cover. Suitable cover is usually abundant, however, so antelope excluded or disturbed by the bedding of deer, sheep or larger ungulates soon find unoccupied bedding areas.

To improve the food available to blackbuck, patches of such grains as wheat or oats can be planted and left standing. More study is required to learn how to manage such plantings and how substantially they would contribute to total nutrition. However, it is known that the blackbuck on one south Texas ranch concentrated on the standing oats planted for the wildlife (Robinson pers. comm.). Blackbuck in some areas of India have been accused of maintaining themselves largely on the growing cereal crops (Forsyth 1871, Dharmakumarsinhji 1967). Wheat is named most often; the depredations appear to have been heaviest on the tender, young wheat shoots (Forsyth 1871, Baker 1890, Stockley 1928). Dharmakumarsinhji (1967) noted that his captive blackbuck showed a special preference for green wheat stalks as supplemental feed.

Some ranches offer pelleted feed or corn and often hay in small amounts just to keep the animals used to supplemental feeding. Then if emergency conditions develop during the winter, an increased ration may save the animals. In any case, the animals should be in good condition before winter begins. Other ranches maintain their game on feed. Once begun, these expensive programs cannot be stopped without mass starvation unless almost all the animals are first removed from the pasture. Maintaining numbers above carrying capacity results in range degradation because the animals do not stop eating native vegetaion even when dependent on feed.

In addition, increased animal density magnifies parasite problems, and worming becomes necessary. However, worming blackbuck that are loose in a pasture is neither practical nor effective. Worming is not effective for the same reason that raising blackbuck in combination with other exotics on feed rather than on natural forage is inefficient. In both interspecific and intraspecific competition at feeders, aggressive animals may get more feed, and consequently more worm medicine, than intended while others may get none at all. In intense competition with other species, blackbuck do poorly. Only adult males push through the crowd with any regularity. Even then, they are usually forced out again after a few mouthfuls at best. In addition, blackbuck males spend part of their time displaying to females instead of trying to eat. By the time a territorial male stops displaying to the other blackbuck who arrive at the feeder, little or nothing is left.

Big ungulates like nilgai, oryx and cattle are of higher biological rank (Hediger 1940) than blackbuck. Mature blackbuck males fre-

quently hold their own against axis males (Fig. 12-1) and dominate fallow bucks in velvet. Otherwise, they are generally inferior to males of other species, but superior to females. To defend themselves or to enforce distance, a blackbuck will swing its head in a butting motion directed at the other animal. In males, this brings the frontal surface of the horns down against the target, but in females it is an ineffective gesture. Since blackbuck neither bite nor kick, the hornless females are defenseless against these two forms of attack which are commonly used by deer. Not surprisingly, blackbuck females are dominated by all other common Texas ungulates. Only the fallow females eat peaceably next to the blackbuck females; like the blackbuck females, they wait to eat until only a few animals of other species are left at a feeder. These relationships must be allowed for if supplemental feeding is planned. Furthermore, the quantity a particular animal may get of any special additive, such as worm medicine mixed with the feed, is also affected.

To help all species and inferior as well as superior animals to reach feed, the pellets, corn or hay should be spread out rather than all placed in one trough. Then blackbuck can dart in and get something to eat. If a territorial buck is keeping bachelors away from a feeding spot within his territory, then feed should also be left 140 m (150 yd) or more beyond his boundary at an unoccupied spot frequented by the bachelors.

Any supplemental feed should be set out at times when the blackbuck would normally be grazing. Otherwise they may visit the feed only briefly before withdrawing to bed. When they come back, most of the feed may be gone, trampled or contaminated from lying on wet or soiled ground. Because it is the most obligatory, the midmorning rest period (0830-0930 CST) is the main interval to avoid. Grazing is most intense just after dawn, but the ground is often wet and the natural grazing is at its best then. Thus, the most advantageous time to feed is just as the blackbuck are ready to end their midmorning rest.

Productivity

Although a blackbuck female bears only a single fawn, she can have two fawns a year because the average fawning interval is 6 months. Some females are quite consistent, but the variation among fawning intervals results in blackbuck females averaging closer to three, rather than four, fawns in 2 years. (For a fuller discussion of these aspects, see Chapter 6.)

In one of the nonhunted blackbuck populations studied most closely, there were 52 females of reproductive age for every 100 blackbuck older than fawns. At 1.5 fawns per reproductive female per year, this would indicate a yearly fawn crop of 78. The equivalent of 72 fawns were tallied, but not all of these would be expected to reach maturity. Assuming a 1:1 sex ratio among the fawns, fewer than 36 males would survive the 2.5 to 3 years necessary to attain at least minimum trophy value. Since some of the males must be left to maintain breeding territories and more must be left so that there will always be a bachelor association to perpetuate the normal social order, the huntable figure must be less than 36 percent of the 100 blackbuck older than fawns.

Of course, the percentage will fluctuate with fawn survival and the number of territorial males in a given year, so the population must be watched in order to adjust hunting quotas. For example, one rapidly expanding population had a 31 percent mortality rate among fawns instead of the 8 percent (difference between 78 fawns expected and 72 fawns observed) for the stable population used here for illustration. Regardless of the difference in fawn mortality rates, the stable population had more huntable males by virtue of its large size. Characteristically, the expanding blackbuck population was small. Its morality rate would be expected to change with increasing numbers, necessitating calculation of new quotas.

The present Texas hunting system concentrates on males. To prevent exceeding the carrying capacity, females must also be removed. Trapping for sale as breeding stock solves part of the problem, but doe hunting would also help. Low fees, the table qualities of the meat and the beauty of the tan and white hide could be used as inducements. In the absence of doe hunting or trapping, wild predators must be relied upon to keep down numbers. Such predation affects fawns most, both males and females.

Carcass and meat characteristics

Blackbuck ranks high as a table meat. Nevertheless, carcasses are too small to offer potential, other than as a specialty item, for a commercial market in the United States.

Weights

The average live weight for 40 adult males was 37.5 kg (82.8 lb), and the average live weight for 22 adult females was 26.5 kg (58.5 lb). All these animals came from Texas ranches. Excluding one truly exceptional Texas buck of 65.3 kg (144 lb), the Texas male range of 19.5 to 56.7 kg (43 to 125 lb) compares reasonably with Meinertzhagen's (1938) range of 34.9 to 42.6 kg (77 to 94 lb) for 21 Rajputana males who were not selected for size. The two antelope females he measured in the same district were 32.2 and 38.6 kg (71 and 85 lb), while the Texas females ranged from 19.0 to 33.1 kg (42 to 73 lb). (See also Chapter 6.)

Average field dressed weights for these two classes in Texas are 27.6 kg (60.8 lb; N = 41) for adult males and 19.1 kg (42.1 lb; N = 9) for females. Field dressed animals have been eviscerated only. Once the head, hide and hooves are removed, the carcass is lighter; therefore, even though the meat is highly regarded, the blackbuck has no foreseeable value as a commercial protein source like beef or pork for a low-cost, high-volume market (Teer 1974).

Palatability ratings

A survey conducted by the blackbuck project indicated that the people who hunt blackbuck generally save the meat if they do not live so far away that transport is a problem. Because those who have blackbuck meat share it with family and friends, nonhunters as well as hunters have eaten it. Out of 35 persons, only one disliked blackbuck, and she does not care for game meat from any species; two others liked it, but with reservations. Rated on a 1 to 10 scale (1 = best), tenderness averaged 4, flavor 3, and juiciness 4 (N = 34). In other words, people rate blackbuck meat as reasonably tender, of good flavor and of better than average juiciness.

Except for the one respondent who does not like any game meat, the only scores below 6 were three of 7 for juiciness and one 7 rating for flavor. The lower scores for juiciness point up the fact that blackbuck, like many other game meats, tends to be dry because it lacks the heavy marbling characteristic of beef. Correlating juiciness scores with intramuscular fat content of cooked meat indicates that the most important influence on juiciness is cooking procedure (Bratzler 1971).

Cooking

Some people recommend blackbuck cut into thin steaks and fried quickly. It may receive a flour coating first, depending on preference. Othe people have blackbuck barbecued with a sauce. Cooking as a roast requires moist heat. Cooking quickly, adding fat, using moist heat or any technique that compensates for the inherent dryness should give good results.

Methods for optimum meat quality

Hosch's (1976) controlled experiment on the way to get the best table results from whitetailed deer meat brings out a number of points which should be considered for blackbuck as well. Some of the practices affect tenderness which both Bratzler (1971) and Ables *et al.* (1973) regard as the most important palatability factor on acceptance of any meat. Other factors affect juiciness and still others affect flavor. An "off" flavor ("gamy" or "wild") is the chief reason some people dislike game meats. Properly handled, blackbuck should be devoid of any objectionable gamy flavor.

Flavor differences between the sexes can vary according to species. Whitetail males shot during the fall have a stronger gamy taste than females, while meat from whitetail female carcasses aged one week at 4.5 °C (40.1 °F) has a more intensified flavor of a desirable, rather than gamy, type (Hosch 1976). However, meat from steers and from an adult male nilgai antelope rated better in flavor than that from female beef cattle or an adult female nilgai (Ables *et al.* 1973).

Indian opinions of blackbuck meat differ widely. Blanford (1888-91) calls it "excellent," Lydekker (1907) says "good," though not comparable to chinkara, and Baldwin (1876) deems it "only tolerable." Nevertheless, the last author concedes that the saddle from an old buck

is good at certain seasons and that cured hams have an excellent flavor. Campbell (*in* Jerdon 1874) also mentions that he considers meat from old bucks "infinitely superior" to meat from young bucks.

Meat from relaxed animals dropped dead on the spot is more tender than that from animals who run even a short distance before death or who are excited in any way (Hosch 1976). This is another argument for a clean kill. Stress increases toughness, because stressed animals enter rigor mortis faster (von La Chevallerie and van Zyl 1971) and with the muscles in a more contracted state (Hosch 1976).

Carcasses should be eviscevated as soon as possible. If the weather is not hot, delays of as much as 12 to 16 hours can be tolerated (Hosch 1976); longer delays risk development of a gamy flavor.

Leaving the skin on during aging helps in two ways. It retards bacterial growth (Hosch 1976) and it aids water retention, thus enhancing juiciness at the same time. Hosch (1976) reports that the maximum bacteria counts from the meat surface when the skin was left on for a week of aging were less than 10 percent of the counts when the skin was removed before aging; all counts were within safe limits.

Aging one week at 4.5°C (40.1°F) increases tenderness (Hosch 1976) by retarding and extending rigor mortis and by increasing water holding capacity (Pearson 1971). Smith *et al.* (1974) recommend that aging be limited to one week to avoid increasing bacterial deterioration. Because of higher bacteria counts at the wound site, they also suggest that wound areas be removed before aging.

Hanging the carcass by the pelvis at the obturator foramen (Fig. 12-2) avoids the toughening of choice table cuts which occurs when a carcass is hung by the hind leg. This unnatural position (hind leg suspension) results in a shortening and consequent toughening of the round and loin muscles. (Hostetler *et al.* 1970).

Bones should be left in place when the meat is cut, wrapped and frozen. Severing the muscle attachment to the bones allows muscle fibers to contract which increases toughness (Hosch 1976).

Summarizing this discussion on procedures for best meat quality gives the following guidelines: Decide whether to hunt a male or a female. Select an unexcited individual and kill it so that it dies instantly. Field dress the carcass as soon as possible. Leave the skin on for aging, but before aging cut away the area around the wound or wounds. Age one week at refrigeration temperatures with carcass hung by the pelvis (see Fig. 12-2). Cut, wrap and freeze without boning. Use a cooking method that compensates for the dryness of the meat. Enjoy your blackbuck meat.

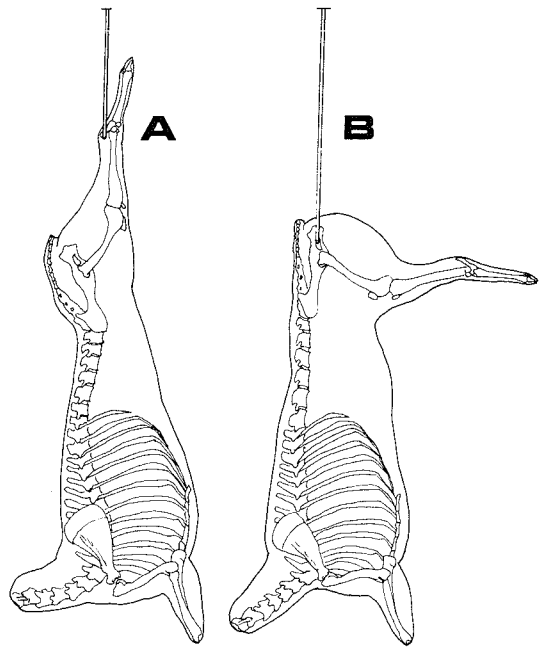


FIG. 12-2. Carcass hanging methods: (A) conventional and (B) "tenderstretch" method developed at Texas A&M University to maximize tenderness of more of the best table cuts.

Stocking and handling

Blackbuck are generally compatible with the other exotics frequently kept in Texas as long as any supplemental feed is spread out to relieve crowding and to minimize the risk of injury.

Fencing and pasture shifts

Under normal circumstances, standard 1.2 to 1.4 m (4 to 4.5 ft) sheep and goat fencing — square mesh — is adequate to contain blackbuck. However, high fencing is still recommended. Blackbuck can jump gates of 2 m (6.6 ft) or more if cornered (White pers. comm.). In addition, stotting in an alarm situation can

carry a blackbuck, seemingly unintentionally, over low barriers like the standard Texas sheep and goat fences if the animal is near the fence when startled (Taibel 1937; Fuchs, pers. comm.). (Jumping is described in Chapter 4.)

Maintaining fences in good condition is important although not as critical as with some deer species because blackbuck are conservative in their movements. Some living in an area being developed for housing stayed even after the fence was removed and building started (M. Sikes and T. Sikes pers. comm.). However, any gaps, whether caused by white-tailed deer pushing holes in the wire, floods washing out water gaps or gates left open, may eventaully be used by at least a few blackbuck as they travel to and from feeding areas. Even large bucks use holes only 38.1 cm (15 in) high by 68.5 cm (27 in) wide. Some bucks also develop the habit of jumping cattle guards.

Although there is a low level of immigration and emigration where fence condition permits, antelope that leave are likely to return. One buck that entered a pasture on 27 April 1973 and left on 12 March 1974 came back again briefly on 22 December 1974. The tendency to resume territorial status on the same ground formerly held can also bring a buck back even though he has crossed into another pasture in the meantime.

This same attachment to an area means that blackbuck are slow to spread out of the pastures where they are stocked. On two ranches that stocked blackbuck perhaps 20 years ago, a large population has developed in the one pasture where the antelope were originally released. Only comparatively small populaitons inhabit neighboring pastures. Carpenter (per. comm.) recorded enough blackbuck in one of these populations for densities as high as one blackbuck per 1.4 ha (3.5 ac) prior to the year when density dropped there and sightings in nearby pastures increased. Nevertheless, even after this shift, the original pasture still had more antelope than the surrounding pastures.

Pastures for exotics are often 120 ha (296 ac) or more; on large ranches fence upkeep can be a full-time job. The continuing cost in labor and materials comes on top of the original expense. In 1972 a 2.1 m (7 ft) game fence could be built for about $2,500 a mile (Ramsey 1972). At that time, a half section of land (130 ha; 320 ac) plus a new, 2.1 m (7 ft) perimeter fence required an investment of about $55,000 (Ramsey 1972). Prices are still rising. Even before purchases of brood stock — a minimum of approximately $200 a head for blackbuck — feed, vehicles and so forth, a game ranch is an expensive operation.

Capture

Catching, handling and transporting blackbuck demand experience. Drug darting is generally impractical for blackbuck under range conditions, since they frequently are too wary to allow approach within the 55-m (60-yd) range within which a dart gun, such as Palmer Chemical Company's Long Range Projector, is effective (Palmer 1973). Even if they can be hit, they are thin skinnned, small and delicate and do not hold up well if injured (Robinson pers. comm.).

Box traps like those used for deer rarely tempt blackbuck (C. Ahrens, pers. comm.). The drop net has been most successful for catching large numbers of blackbuck on Texas rangeland. As originally designed, it is a 21.3 by 21.3 m (70 by 70 ft) square of 8.9 cm (3.5 in) mesh made of # 60 nylon rated at 250 kg (550 lbs) breaking strength (Ramsey 1968). Each corner is winched up to a 5 cm by 3 m (2 in by 10 ft) length of pipe chained to stakes. The center hangs from a 3.2 cm by 3.6 m (1.25 in by 12 ft) length of lightweight steel tubing (Ramsey 1968). The net should be suspended 2 to 2.5 m (6 to 8 ft) above the ground to keep deer or cattle from catching antlers or horns (Temple 1976). An area 26 by 26 m (85 by 85 ft) must be cleared for the net (Ramsey 1968). Rocks, limbs, troughs or tall vegetation might keep the net from falling to the ground or might injure a captive.

Some variations obviate using blasing caps for release by having a pin through the center pole. To yank out the pin by pulling on the attached cord, however, the operator must be in a blind close to the net. Some nets have mesh flaps which are folded back on top of the square so that they will swing out and down as the net falls. The flaps then serve as sides which discourage animals from dashing out at the last moment. All bait is placed at least 3 m (10 ft) from the edge to concentrate animals under the center of the net. This also helps to keep them from escaping as the net descends. A high con-

centration of the target species is unnecessary if the animals respond to bait. For example, one ranch removed the last five blackbuck from a pasture of almost 365 ha (902 ac) in three drops of the net over a period of several weeks.

Inexperienced crews (three-man minimum) should not be expected to handle more than six animals at a drop (Ramsey 1968). An experienced four-man crew can handle up to 25 animals from one drop (Temple 1976). The kill ratio resulting from internal injuries and broken bones is approximately 5 percent (Temple 1976).

Heat is another danger. Of 52 blackbuck once netted by two men, at least 12 died of heat exhaustion because the men could not get to all of them soon enough (Temple 1976). After 25 minutes the animals begin to die rapidly (Temple 1976). Trappers are therefore advised to catch only what can be untangled within 25 minutes and to trap only on cool days or after late afternoon cooling begins.

Trapping during peak fawning should also be avoided. The best times to trap are when natural forage is in shortest supply. Otherwise blackbuck often fail to come to bait. In the Texas Hill Country the favored times for netting attempts are in early to mid-August and again during mid-November through February or March. Obviously, the net must be put up long enough in advance for the animals to become familiar with it before the first trapping effort.

A net corral with one long wing might work for catching blackbuck in large numbers. Attempts in Israel to catch mountain gazelle using the same plan Pienaar had employed for springbok in South Africa were successful once the drivers stopped trying to rush the animals (Walther pers. comm.). It is imperative that the animals be driven very slowly so that they enter the trap at a walk. Past failure of Texas drives was probably caused by drivers coming too close or moving too fast, especially when the animals neared the corral gate. Once panicked, blackbuck turn back and flee even if it means running headlong into a chain of drivers (Ramsey pers. comm.).

In Israel a net circle enclosing about 1 ha (2.5 ac) of the top of a rise was left with the net down for about a quarter of the perimeter; when driven gazelles came to the wing, they followed it into the corral, and a truck then drove away pulling a rope that raised the net gate. The high ground in the center of the pen kept the animals from seeing as they entered that the far side was blocked. Running the animals against the net walls after dark got them tangled so that handlers could remove the captives; no broken bones were reported. In this type of capture, as with a drop net, the animals should not be left for a long period or allowed to remain in the hot sun before being put into crates and shipped. (Walther pers. comm.).

If a catch pen is used for holding and loading, walls should be at least 2.3 m (7.5 ft) high. Solid walls are better than mesh and are required for the chute and gates. A circular pen is easier on both men and animals than a square one because there are no corners to stop the animals when they are moved along the fence toward a gate. After the gate, the chute which funnels the animals to the truck, trailer or treatment site should also curve. This keeps the animals in the rear from seeing the trailer and turning back. Working penned blackbuck in dim light or with flashlights after dark aids in keeping the animals calm. At all times, however, the watchword must be patience. As Temple (1976, p. 143) writes, "The blackbuck antelope caught in a pen reminds me of a firecracker. If worked slowly and skillfully, they can be loaded with ease. If one gets them excited, they can be the most difficult common Texas exotic species of all. I have seen five or six blackbuck break their necks." Temple continues, "just leave them alone until they settle down. This point cannot be overemphasized."

As with deer, blackbuck can be handled safely and held still if pressure is applied to the nerve running to each of the hind legs. An arm tightly circling the animal at the flank level can do this. When more convenient, one hand grasping the area below and behind each flank will have the same effect. Taking a blackbuck out of a net is usually easiest when the hind legs are freed first and held still by one man while another frees the rest of the animal (Temple 1976). If there are enough people, a third should help manipulate the antelope. Especially when immature bucks are held by the horns, outward pressure should be avoided, or the attachment of the sheath base to the head may be strained.

Shipment

To minimize stress and to speed recovery, blackbuck should be given a mild tranquilizer and a long-lasting antibiotic as they are confined for shipment. In Texas pronghorn relocation operations the number of deaths during transport was high before the years when such shots were given; when shots were started, losses dropped to less than 3 percent of 1,117 pronghorns trapped during the next two fall seasons (Litton 1975). The antibiotic must never be administered orally because it would disrupt the bacteria populations on which ruminants depend for their nutrition. If each animal is to be weighed to determine proper dosage, a large-capacity platform scale can be rolled up near the net while the animals are being untangled. A hefty man who is used to working with animals is weighed. Then he holds each animal as it is extracted and the two are weighed together. The difference is the blackbuck's weight. An operator familiar with the scale can take the weight in less than 2 minutes per animal if the man holding each animal can keep it still for the critical few seconds. If more than six blackbuck are to be weighed in quick succession, it is advisable to have a second weighed man alternate with the first.

The animals should be transported immediately from capture to release site. Trapping late in the afternoon means hauling can take greatest advantage of the cooler evening and early morning hours. To aid cooling the containers should have air holes in the upper walls. Fortunately, blackbuck are not as sensitive to light leaks as are confined axis deer, but a darkened compartment is still recommended to help keep the blackbuck calm.

A covered livestock trailer with straw bedding on the floor and plywood lining the walls is often used. Temple (1976) allows a minimum of 0.4 m^2 (4 ft^2) floor space per deer for short trips and 1.4 m^2 (4.5 ft^2) per deer for trips of 2 days or more. Blackbuck males are usually kept apart from females and at least the older males put in separate crates for any but short trips. Any horned blackbuck not shipped in individual crates or compartments should have his horn tips covered with a 15 to 20 cm (6 to 8 in) length of flexible tubing; a cut-up garden hose works well. Epoxy or tape can be used to hold it in place for long trips. These sleeves will drop off in a few weeks if handlers forget to remove them when the blackbuck are turned loose.

Release in brush rather than in open areas helps keep the animals from running far. In brush, they can quickly get out of sight of their captors and there are more obstacles to slow them. Flighty animals like blackbuck should never be freed facing an obstruction. As zoo men have learned, raising the crate door behind the animal rather than in front of it can induce it to back out slowly. If there is a wall or fence close by, positioning the crate so that the animal is facing the obstacle and very close to it and then opening a rear door should allow a safe release. If the animal does not come out immediately, handlers should not shout or bang on the box but just leave for a couple of hours. The animal should come out of the box on its own even though this may take hours; once the box is opened, the people should withdraw.

Brood stock age and sex composition

Trios of two females and one male are often sold for stocking. Starting a new population in a pasture of 32.4 ha (80 ac) or greater, an owner frequently stocks more animals. Rapid development of a normal social order helps to insure successful establishment of a breeding population. This takes a minimum of eight blackbuck. Three females, including at least one fully adult individual, form a small breeding herd. With three females rather than two, an inflexible superior-inferior relationship that might interfere with reproductive success would be less likely to form. Stocking three mature males gives two bucks each other's company if the third manages to monopolize the pasture. Otherwise it should provide the territorial bucks with one or two neighbors. In either case, inbreeding would be reduced because there is a good chance that not all the fawns born before a male bred in that pasture reaches maturity will have the same sire. The final two animals should be males between 1 and 1.5 years old. By 1 year, immature males have left the female group. Therefore, the trauma of transplatation will not be added to the trauma of being driven out of the female group by the adult bucks. If all the adults are territorial, the youngsters will keep together. If one or two of the adults are bachelors, the bachelor association will have their leadership.

Until the female group grows larger, the chances of there being a male fawn without male agemates are high. If there were no bachelor association, this male fawn would lack normal companionship when forced away from the females. Insuring that there is a bachelor association, removes this possibility. After the 1 to 2 years when the two males stocked as immatures are old enough to try for territorial status, the chance of a male with neither agemates nor at least one bachelor to join when forced out would be small.

Young fawns should not be used for stocking unless accompanied by the mother. A female will nurse only her own young, so any separated fawns not yet old enough to support themselves on vegetation will die. Fawns are 6 to 8 weeks old before they are grazing for as much time as the adults; 2 to 3 months is the transition period during which nursing attempts disappear and diel activity rhythms come to match those of the adults.

Hunting and sporting qualities

Ringed, spiral horns of adult length make a trophy blackbuck. Although a few hunters find a tan and white coat extremely attractive, most value at least some darkening on the forequarters. The most prized trophies show an almost uniform dark brown or black in the pigmented coat areas. Within the adult range, neither horn length nor depth of color denotes age. Some 3 or 4 year olds have horns longer than bucks several years their seniors. Similarly, some newly mature bucks turn darker their first fall than others ever do. (For more on age in relation to horn growth and coat color, see Chapters 4 and 7.)

Dark coat color

Most grown bucks darken in the fall. By late November and early December, the first bucks that darkened are still dark and the last to change have reached their maximum depth of color. However, some bucks, particularly territorial males, remain dark all year. Thus, ranches can offer blackbuck hunting at any time. State laws do not generally regulate seasons for exotic game. (Legal aspects are reviewed briefly in Chapter 11.)

Hunting methods

Common hunting methods employ blinds, searching in a vehicle or stalking on foot. If placed in an area heavily used by blackbuck, blinds can be successful. The blind must be thoroughly familiar to the animals, of course, so that they will not hesitate to approach. Vehicles are effective when large distances must be covered to locate game. However, the most challenging and sometimes the only possible method for working close enough for a shot is to walk or crawl. For this type of hunting a buck is often watched in advance to pinpoint his main resting places. These generally are spots which give the buck excellent visibility, but they have the advantage for the hunter that they are used regularly.

Selection for harvest

With all methods and especially with the last, a manager must be careful that he does not lose all of his territorial bucks. Because they are found predictably in limited areas and use the same few resting places day after day, they are the most vulnerable. Also, during the summer, it is mainly the territorial bucks which have desirable dark coats. Since territorial bucks are the breeding bucks, a self-sustaining population demands an adequately functioning territorial system. In unhunted populations these bucks are usually replaced one at a time so that a new owner has old neighbors. If too many territory owners are shot in too short a time, then even an area with a long history of successful territories will be abandoned. Once shooting stops, it may take months for the area to be reoccupied.

When selecting which bucks to take, a manager should remember that active territory holders can help perpetuate certain varients of the normal horn form. Carpenter (pers. comm.) reports that on one ranch horns with a narrow spread have become quite common. On another Hill Country ranch a surprisingly high proportion of the immature males are developing an extremely open spiral and a narrow spread like those of a good territorial buck in the same pasture. This adult buck has been passed over several times in the hunting program because some hunters consider his horns make him a less desirable trophy even though his coat has developed maximum black color.

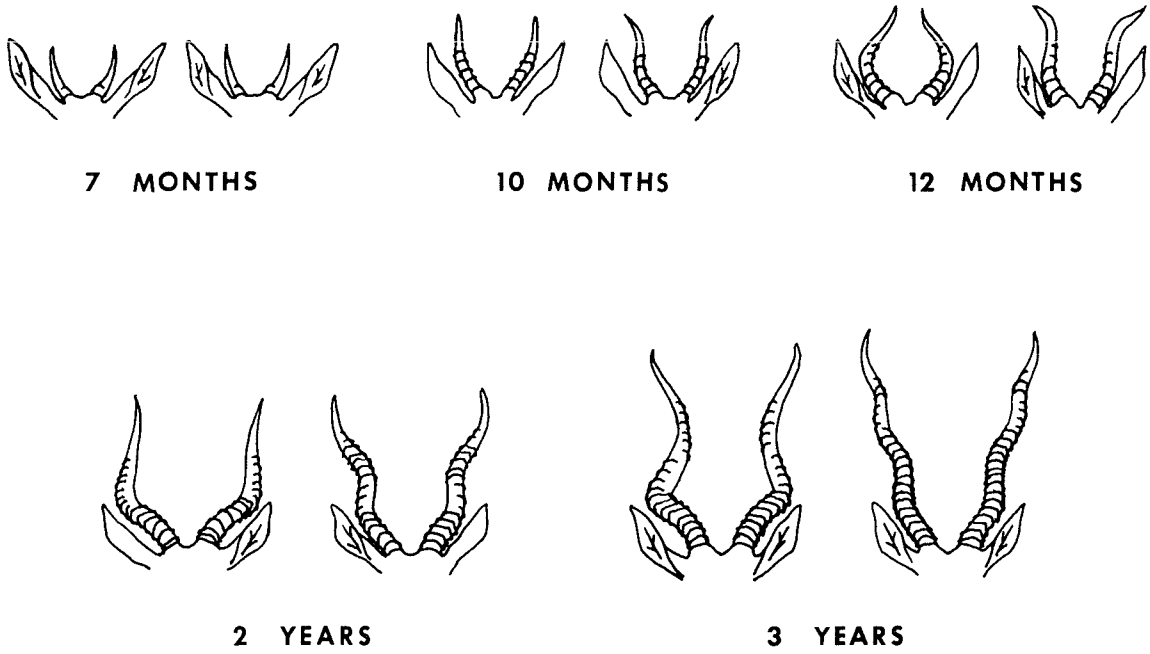


FIG. 12-3. Comparison of the development of open spiral horns (left) with horns of average form. The difference is not obvious until 11 months of age.

Having been left to breed, he is now producing future trophies of his own type. Ranches stocking blackbuck trapped in this pasture are introducing animals of this horn varient along with bucks showing more average forms. A blackbuck who will develop an exceptionally open spiral cannot be picked out until about 11 months of age. At this stage his horns have not yet turned outward for the first time like the horns of other bucks showing comparable horn size (Fig. 12-3). Many young males are trapped and relocated before this stage is reached.

The horn form most attractive to a hunter, a photographer or other paying guest is a matter of personal preference. At present there is a tendency for those hunters who have formed any opinion to favor a particularly wide spread with twisting of any sort except open. An open spiral may become popular in the future. A wide spread can make horns of any length appear longer. Most ranches have a majority of horn forms with intermediate spread and moderate twisting, a few bucks with wide spread and tight or average twisting and only an occasional buck with a spiral open enough to reach adult length without completing at least three twists. Bucks that do have an open spiral often have a narrow spread. (Horn spread and twisting are discussed in Chapters 2 and 8.)

Rifle hunting

Calibers recommended by early sportsmen in India include .256, .275, .300, .303, .400, .450, .500 and .577 (Baker 1890, C. 1902, Stockley 1928). C. (1902) summarizes his 18 years experience hunting blackbuck by judging .303 caliber the most successful, .250 caliber inefficient because too many bucks go away wounded and .500 caliber too much rifle for this size animal. Light, "rook" rifles of .360 and .380 caliber are generally condemned for their high incidence of blackbuck hit but lost (C. 1902, Stockley 1928). Authors from before the turn of the century tended to cite large calibers because many of the longarms previously popular were less accurate than modern guns. To put an animal down with a badly placed shot, the bullet must transfer more energy to the target.

A Texas poll shows that the .243 is presently the most popular rifle caliber for use on blackbuck. The questionnaire went to hunters, guides, ranch managers and ranch owners who have hunted blackbuck themselves or who have blackbuck hunts on their ranches. The .22-250 was judged marginal unless handled by some-

one very familiar with his gun. The .30'06 is generally considered larger than necessary, but it certainly does the job. Thus, it earned three votes because it is a good choice for some of the larger animals with which blackbuck commonly share pastures and so can be carried as an all-purpose hunting rifle. Other votes went to the .257, .264, .270, .3030 and 6 mm. Above all, the hunter should know his gun well enough to make a quick, clean kill. A poor shot or insufficient energy transferred to the target means suffering and waste if the animal is lost and suffering and tougher eating if it is found (Hosch 1976).

Some of the respondents also commented on ammunition type. On the whole, heavy bullets that would not separate from their jackets when they expand during impact were recommended. Few people wanted the bullet to fragment once inside. Small caliber varminter-type cartridges are inadequate because they are likely to blow up on the surface without penetrating. Some hunters try for a bullet that will pass through the body cavity and lodge just under the skin on the far side while others want the bullet to pass out again so that there is a clearer blood trail to follow if the antelope does not drop immediately. None wanted such high velocity that the bullet would pass through and out again without losing most of its energy.

Almost everyone favored a broadside hit just behind the shoulder or through the shoulder into the heart and lung area. Although sometimes recommended for deer, neck or head shots are an easy way to miss a quarry as small and wary as a blackbuck. While neck and head shots waste the least in table cuts, they damage a trophy cape.

Hill Country hunters commonly must take their shots from 100 m (109 yd) or more. Comments from India reflect a similar situation. There, 100 m (109 yd) is about the minimum, with ranges of 200 to 250 m (220 to 275 yd) not uncommon, especially in flat, open country where stalking is more difficult; 140 m (150 yd) is about the average (Jerdon 1874, Baldwin 1876, Baker 1890, C. 1902, Stockley 1928). Blackbuck generally are harder to approach closely than other Indian game. Of 43 ungulates and 3 animals of other kinds that Stockley (1928) shot, only blackbuck, Kashmir stags, urial, Sind ibex and chinkara were bagged at distances of 180 m (200 yd) or more; all the rest were shot from distances of 32 to 165 m (35 to 180 yd).

Photography

As nonhunting tours or "photo safaris" become increasingly popular, offering a memorable visual experience becomes more important. Viewers see more early and late in the day. Fortunately, on mild to hot mornings blackbuck remain in the open longer than do deer. Thus, extremely high film speed is not always necessary. However, glare and mirage pose problems by mid-morning. The best opportunities for pictures often come just after sunset, and then fast film makes a crucial difference. Concentrating photographic effort from August through December when more bucks are darker increase one's chances of catching a truly black blackbuck in a dynamic pose. Late November and early December during bright, sunny weather are ideal. Any time is good, however, if one can find an especially favorable viewing situation in an area frequented by a dark buck. For stationary watches, a photographer should set up so that at least one territorial male is likely to stay within camera range. A territorial male is most likely to be involved in many different activities within a short time span, and antelope of all social categories appear in his vicinity sooner or later.

The best advice for blackbuck is to use the longest telephoto lens available. They are small animals and keep their distance. This makes them photographically one of the most poorly represented of the Texas exotics, even though they are one of the most striking to watch. Even in a zoo enclosure, a portrait close-up can require a 400 mm lens. If one checks the light on pasture blackbuck in advance, has the exposure already adjusted and the shutter speed set at least at 1/125 (preferably 1/250), it is sometimes possible to drive within range, stop and shut off the engine (so the camera will not vibrate), rest a 400 mm to 600 mm lens combination on a sandbag across an open window frame and get a picture before the animals leave. The lens should be set on infinity and refocused fast if the blackbuck are closer. With a 1,000 mm lens combination (minimum 800; 1,300 is not too much), one can park far enough away to keep from disturbing the black-

buck if they are accustomed to stationary vehicles. This offers a chance for a greater variety of shots. Blackbuck move fast, so the prudent photographer takes one picture as soon as possible and only then readjusts the camera if something such as exposure, shutter speed, steadiness or framing did not seem right. The animal or animals should fill the view finder or they will be lost in the final picture.

Summary

In between the snow and freezing weather that descend every 10 years or so, blackbuck populations thrive on Texas Hill Country rangeland that has large, grassy openings as well as brush. Blackbuck are poor competitors at feeders. Nevertheless, they live compatibly with native wildlife, exotic species and domestic livestock when native forage is sufficient. Removing female blackbuck as well as males would help keep the population from exceeding the carrying capacity of the range. Over population not only causes range degradation but magnifies parasite problems as well. For trapping large numbers of blackbuck, the drop net has been most successful. A net corral might work well if drivers move slowly.

Managers must avoid harvesting too many territorial males or eliminating bachelor associations. Either would disrupt the social order and could interfere with reproduction. Quotas depend on fawn survival and numbers of adult males remaining in each social class. Males with desirable horn forms should be included among those bucks protected.

To help insure optimum meat quality from a blackbuck carcass, select an unexcited individual and kill it so that it dies instantly. Field dress the carcass as soon as possible. Leave the skin on for aging and cut away the area around the wound before aging. Age one week at refrigeration temperatures with the carcass hung by the obturator foramen of the pelvis. Cut, wrap and freeze without boning. Use a cooking method that compensates for the dryness of the meat.

Trophy males exist at all seasons, but the more desirable trophies are easier to find in late fall and early winter when more bucks have darker coats. Similarly, this is an especially favorable time for photographers. A long telephoto lens should be standard equipment for taking blackbuck pictures.

Indian blackbuck antelope are a mainstay of Texas commercial exotics programs. These antelope are attractive and easily obtainable. Although only relatively few males reach full trophy characteristics at the minimum possible age, blackbuck reproduce readily, giving a steady supply of individuals from which to choose. Their capacity for rapid increase also insures populations against disappearance when either natural or man-induced conditions cause a sudden decline. One last attribute which endears blackbuck to all who come to know them is their wild spirit. They are easy to spot when they congregate in the open, but even with continual human contact they remain one of the shyest of all the exotics.

APPENDIX A Scientific Names

This list gives the scientific names for the wildlife species mentioned in the text. If more than one form of the common name appears in the text, the name is alphabetized under the most general form. Taxonomic nomenclature as given in Grzimek (1972-75) has been followed. Ellerman and Morrison-Scott (1966) and Prater (1971) have helped to resolve uncertainties and to supply further information. Domestic animals, groups above the species level and animals whose species identity could not be clearly determined are not listed.

Common Name	Scientific Name	Authority[1]
Addax	*Addax nasomaculatus*	(De Blainville 1816)
African buffalo	*Syncerus caffer*	(Sparrman 1779)
Aoudad sheep	*Ammotragus lervia*	(Pallas 1777)
Axis deer	*Axis axis*	(Erxleben 1777)
Barasingha	*Cervus duvauceli*	Cuvier 1823
Bighorn sheep, Rocky Mountain	*Ovis canadensis canadensis*	Shaw 1804
Blackbuck antelope, Indian	*Antilope cervicapra*	(Linnaeus 1758)
Black-tailed deer	*Odocoileus hemionus columbianus*	(Richardson 1829)
Boar, wild	*Sus scrofa*	Linnaeus 1758
Caracal	*Caracal caracal*	(Schreber 1776)
Cheetah	*Acinonyx jubatus*	(Schreber 1776)
Chinkara	*Gazella gazella bennetti*	(Sykes 1831)
Coyote	*Canis latrans*	(Say 1823)
Dall's sheep	*Ovis canadensis dalli*	Nelson 1884
Dama gazelle	*Gazella dama*	(Pallas 1766)
Elephant, Indian	*Elephas maximus bengalensis*	(Blainville 1845)
Eland	*Taurotragus oryx*	(Pallas 1766)
Elk	*Cervus elaphus canadensis*	Erxleben 1777
Fallow deer	*Dama dama*	(Linnaeus 1758)
Four-horned antelope	*Tetracerus quadricornis*	(De Blainville 1816)
Fox, gray	*Urocyon cinereoargenteus*	(Schreber 1775)
Fox, Indian	*Vulpes bengalensis*	(Shaw 1800)
Fox, red	*Vulpes vulpes*	(Linnaeus 1758)
Gaur	*Bos gaurus*	H. Smith 1827
Goitered gazelle	*Gazella subgutturosa*	(Güldenstaedt 1780)
Grant's gazelle	*Gazella granti*	Brooke 1872
Hamster, golden	*Mesocricetus auratus*	(Waterhouse 1839)
Hog deer	*Axis porcinus*	(Zimmermann 1780)
Hyena, striped	*Hyaena hyaena*	(Linnaeus 1758)
Impala	*Aepyceros melampus*	(Lichtenstein 1812)
Jackal, Indian	*Canis aureus indicus*	(Hodgson 1833)
Javelina	*Tayassu tajacu*	(Linnaeus 1758)
Jungle cat	*Felis chaus*	(Güldenstaedt 1776)
Kashmir stag	*Cervus elaphus hanglu*	Wagner 1844
Leopard	*Panthera pardus*	(Linnaeus 1758)
Lion	*Panthera leo*	(Linnaeus 1758)
Mongoose, common	*Herpestes edwardsi*	(Geoffroy 1818)
Mouflon sheep	*Ovis ammon musimon*	(Pallas 1811)
Mountain gazelle	*Gazella gazella gazella*	(Pallas 1766)
Mountain goat	*Oreamnos americanus*	(De Blainville 1816)
Mouse, house	*Mus musculus*	Linnaeus 1758
Mule deer	*Odocoileus hemionus*	(Rafinesque 1817)
Musk ox	*Ovibos moschatus*	(Zimmermann 1780)

[1]The authority cited for a scientific species name is the original describer. Parentheses around the authority indicate that the genus name has since been changed. Parasite nomenclature has undergone so many changes that the authority for the most recent generic change is sometimes given after the original species authority in parentheses.

Common Name	Scientific Name	Authority
Nilgai antelope[2]	*Boselaphus tragocamelus*	(Pallas 1776)
Nyala	*Tragelaphus angasi*	Gray 1849
Oryx	*Oryx gazella*	(Linnaeus 1758)
Parakeet, rose-ringed	*Psittacula krameri*	(Scopoli 1769)
Peafowl	*Pavo cristatus*	(Linnaeus 1758)
Persian gazelle	*Gazella subgutturosa subgutturosa*	(Güldenstaedt 1780)
Porcupine, Indian	*Hystrix indica*	Kerr 1792
Pronghorn antelope	*Antilocapra americana*	(Ord 1815)
Rabbit, Old World	*Oryctolagus cuniculus*	(Linnaeus 1758)
Rat, brown or Norway	*Rattus norvegicus*	(Berkenhout 1769)
Red deer	*Cervus elaphus*	(Linnaeus 1758)
Reindeer	*Rangifer tarandus*	(Linnaeus 1758)
Rhinoceros, black	*Diceros bicornis*	Linnaeus 1758
Rhesus monkey	*Macaca mulatta*	(Zimmermann 1780)
Roe deer	*Capreolus capreolus*	(Linnaeus 1758)
Saiga antelope	*Saiga tatarica*	(Linnaeus 1766)
Sambar	*Cervus unicolor*	Kerr 1792
Sika deer	*Cervus nippon*	Temminck 1838
Sind ibex[3]	*Capra aegagrus blythi*	Hume 1874
Sitatunga	*Tragelaphus spekei*	Sclater 1864
Sömmering's gazelle	*Gazella soemmeringi*	(Cretzschmar 1826)
Sparrow, English or European or house	*Passer domesticus*	(Linnaeus 1758)
Springbok	*Antidorcas marsupialis*	(Zimmermann 1780)
Squirrel, fivestriped palm	*Funambulus pennanti*	Wroughton 1905
Squirrel, threestriped palm	*Funambulus palmarum*	(Linnaeus 1766)
Starling, common	*Sturnus vulgaris*	Linnaeus 1758
Thomson's gazelle	*Gazella thomsoni*	Günther 1884
Tiger	*Panthera tigris*	(Linnaeus 1758)
Urial	*Ovis orientalis*	Gmelin 1774
Waterbuck, defassa	*Kobus ellipsiprymnus defassa*	(Rüppell 1835)
Water buffalo	*Bubalus arnee*	(Kerr 1792)
White-tailed deer	*Odocoileus virginianus*	(Zimmermann 1780)
Wolf	*Canis lupus*	(Linnaeus 1758)

[2]In the strict sense, the Hindi and Mahrathi name *"nilgai"* actually means only the cow and *"nilgau"* designates the bull; this combination of *"nil"* and *"gau"* which translates "blue ox" has given rise to the English name "blue bull" which is common in hunting accountings (Blānford *in* Babur 1922, Ali 1927, Prater 1971).

[3]This entry has been prepared on the assumption that Stockley (1928) means the Sind wild goat rather than the true ibex of which the race *Capra ibex sibirica* (Pallas 1776) extends into northwestern India (Ellerman and Morrison-Scott 1966).

APPENDIX B Physiography of Habitat

The following briefly characterizes the geology, topography and climate of the principal blackbuck areas in India. Comparison of native conditions with conditions in an area of successful introductions not only gives greater insight into the requirements of the species but also helps to indicate tolerance ranges.

Most of India is a series of plateaus (Chatterjee 1973, Sarker 1975). Even as far back as the Cambrian, peninsular India has always been land; only temporarily and locally have parts been covered by the sea (Wadia 1973). Except for Quaternary deposits that line the east coast and dot the southern half of the west coast, the only major superpositions are areas of Mesozoic and upper Paleozoic deposition scattered across the Deccan and horizontal basalt beds which spread over more than 1,000,000 km² (386,100 mi²) of the northwestern Deccan at the end of the Cretaceous and into the Eocene (Wadia 1973). Erosion during the next 50 million years cut into this plateau forming the many flat-topped hills of the Western Ghats (Wadia 1973).

From the Vindhya Mountains on the northern boundary of the Deccan to the Himalayas and the other ranges defining the Indian subcontinent on the north, northeast and northwest, stretch the Indo-Ganga plains. Tertiary uplifts of the Himalayas channeled alluvial deposits into the basin between these ranges until it formed a vast plains area of 770,000 km² (297,297 mi²) topped with Pleistocene alluvium (Wadia 1973).

The Indian climate is characterized by extremes. Rainfall in the Thar desert of the northwest averages less than 13 cm (5 in) a year, whereas the average near Imphal in Manipur far to the east is a staggering 1,000 cm (394 in) (Basu 1973). In some areas, nearly all the precipitation falls during one rainy season with little or none the rest of the year (Bābur 1922, Basu 1973).

Monsoon winds dominate the Indian climate. The southwest monsoon ushers in the rainy season. Blowing up over the ranges of the west coast, it starts shedding moisture picked up from the sea. Lush forests and jungle grow along this coast. The mountains are low enough to allow sufficient moisture to reach the interior to support drier woodland and grassland vegetation. Rainfall is heaviest at the start of the rainy season in July or, sometimes, in June and tapers off by October or the end of September; October is hot and humid (Dharmakumarsinhji 1967). By December, the winds have reversed (Basu 1973). The northeast monsoon now blows over the Himalayas. Its trip across the expanses of central Asia means that the winter wind is extremely cold and dry. However, the heights of the Himalayas force enough rain and snow to save India from joining the desert belt which includes parts of central Asia and northern Africa. Not until it reaches the area of the Thar Desert in the west is the desiccating power of the winter monsoon felt again.

The coldest months are December and January when mean maximum temperatures range from about 29°C (84.2°F) in the south to about 18°C (64.4°F) in the northwest (Basu 1973). Mean minimum temperatures range from about 24°C (75.2°F) in the south to less than 5°C (41°F) in the northwest (Basu 1973). Periodic cold waves in the northern plains, sometimes extending into the northern peninsula, can lower the temperature another 10°C (18°F) and bring frost to northwestern India (Basu 1973). Snow falls only in the Himalayas and in Kashmir, not in areas inhabited by blackbuck (Bābur 1922, Basu 1973).

Summer begins in March. At first, there are showers and the days are warm, growing hotter as the season progresses (Dharmakumarsinhji 1967). The winds keep changing direction. By May, mean maximum temperatures above 40°C (104°F) are common in many areas, and temperatures above 54°C (129°F) have been reported in the west; the mean minimum temperature for May exceeds 21°C (70°F) (Basu 1973).

The yearly mean range of diurnal temperature is from about 14 to 17°C (57 to 63°F) in northwestern India and less to the south and east. The minimum range is from 8 to 11°C (46 to 52°F) in the northeast and in the coastal districts. The range is greater in the interior than on the coast and depends on humidity and cloud cover. (Basu 1973).

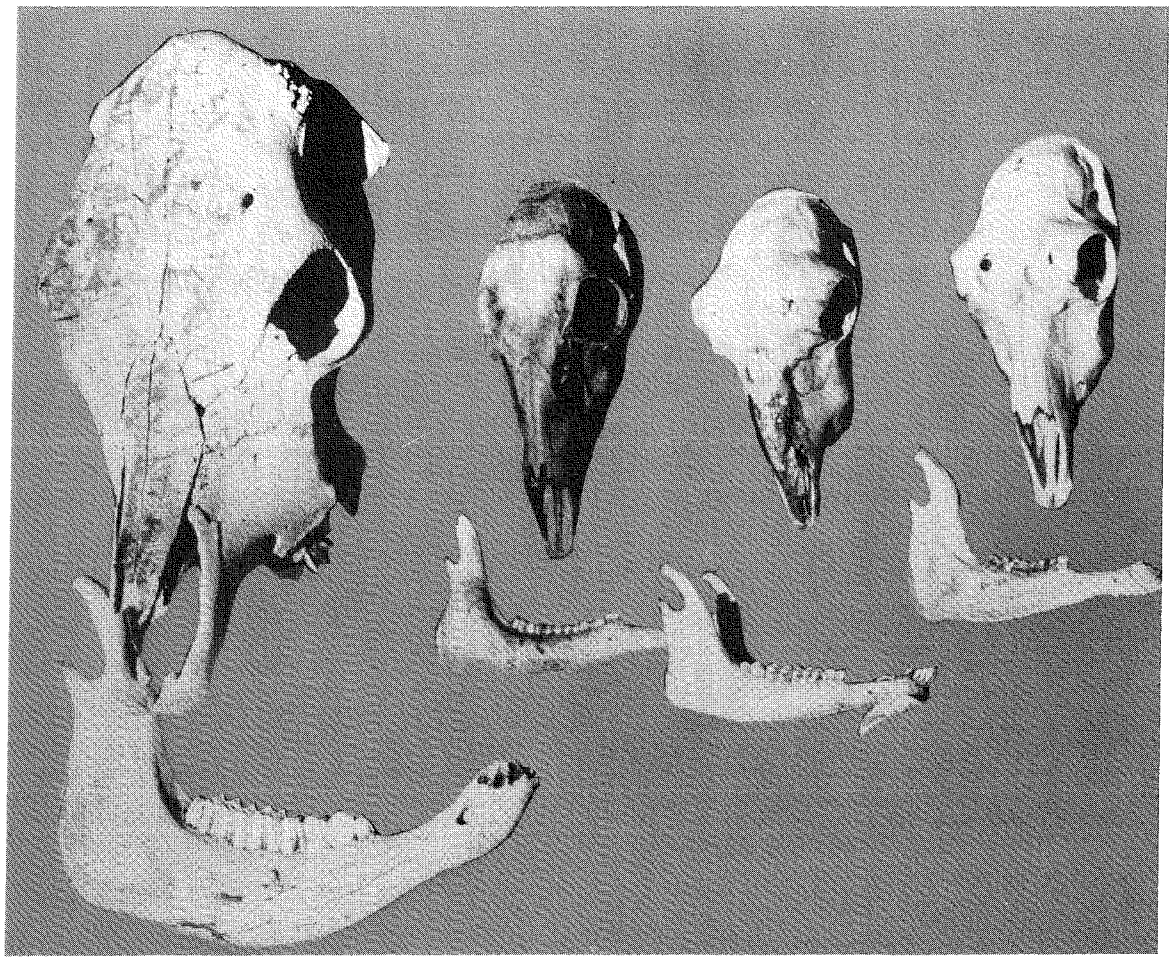
Mean annual humidity varies from less than 50 percent in the Thar Desert to about 80 percent in parts of Assam and along much of India's coastline. In wet weather, relative humidity can rise to 95 percent or even 100 percent; under a hot wind, relative humidity commonly drops below 10 percent. During the day, early dawn is the dampest time; the driest time comes whenever the temperature is highest. (Basu 1973).

Regardless of season, mean wind speeds range from 15 to 25 km/h (9.3 to 15.5 mph) in the Punjab and from 30 to 70 km/h (18.6 to 43.5 mph) in the peninsula. The greatest speeds are registered at heights of approximately 1.5 km (0.9 mi). The transition period between southwest and northeast monsoons favors the development of intense cyclonic activity. (Basu 1973).

Cyclones, plus associated floods, can have devastating effects on local wildlife populations (Stacey *in* Daniel 1967, Rashid *in litt.*). A 1973 Gugarat disaster illustrates the susceptibility of blackbuck to flooding. More than 125 blackbuck in a preserve drowned when late August and early September rains flooded the Jambuva and Dhadhar rivers (Oza 1976).

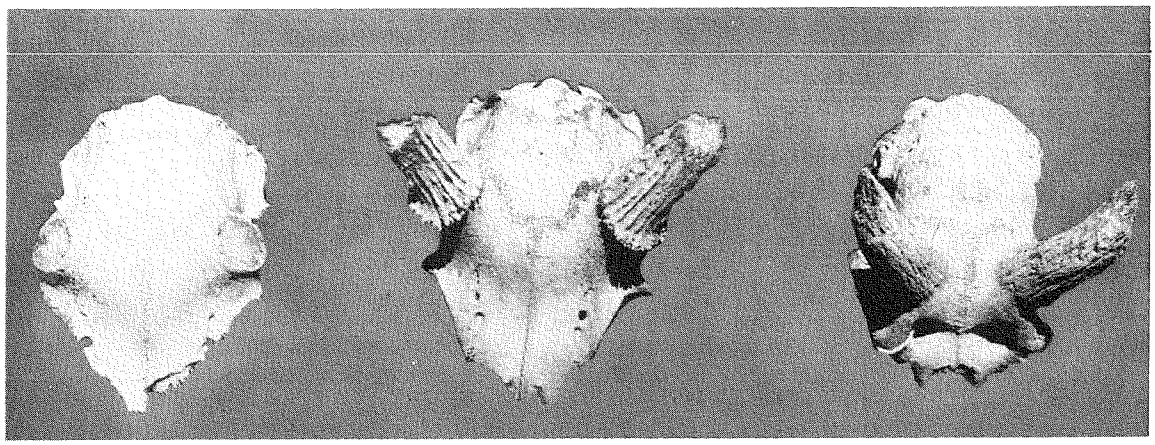
APPENDIX C

Discussed and shown here are the chief characteristics used to differentiate blackbuck skull material from that of other ungulates likely to be present on the same range.



Size: (Fig. C-1)	Cattle (extreme left) and horses are much larger. Deer (whitetail beside cow), sheep (second from right) goats and blackbuck (extreme right) are all in same size range.
Jaw shape:	Deer mandible is narrower and the angle of the mandible more curved. Sheep and blackbuck have a wider mandible with a more square angle.
Cranium shape:	Deer have straighter nuchal crest (viewed dorsally). Sheep, goats and blackbuck have more rounded nuchal crest profile (viewed dorsally), but dorsal surface in blackbuck more highly sculptured with orbits more pronounced.
Preorbital gland site:	Deer have pitted lacrimal bone. Blackbuck have smooth lacriminal depression
Teeth:	Deer premolars and molars bulge outward at neck (just above mandible); 1st incisors shovel-shaped; six molariforms per side in permanent mandibular dentition. Sheep and blackbuck molariforms rise straight from the mandible but 1st incisors are peg-like in sheep and shovel-shaped in blackbuck; five molariforms per side in permanent blackbuck mandibular detentition.

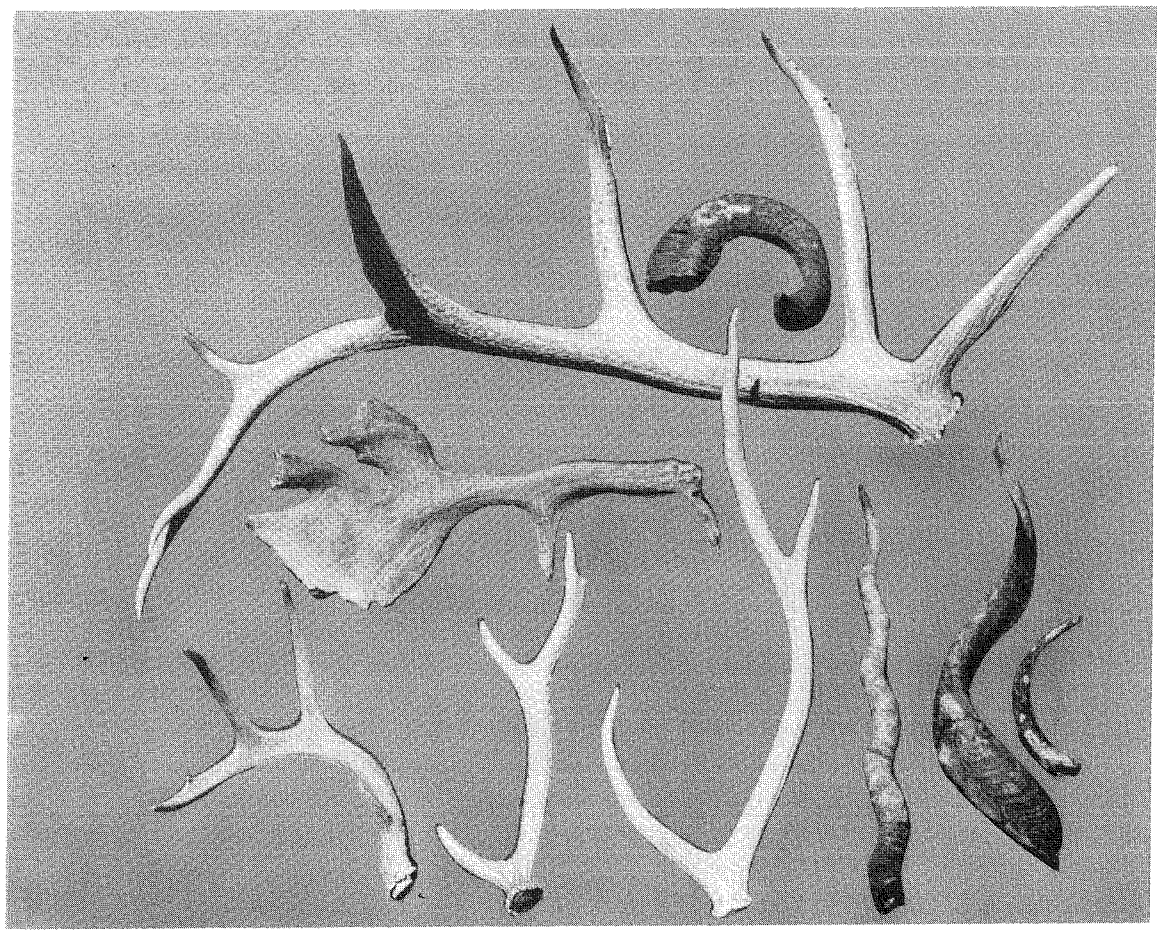
(Continued on next page)



Horn/antler bases: (Fig. C-2)

Deer have definite pedicles whether antlers shed (left) or not (center), and bases rise more laterally over nonrecessed supraorbital foramina.

Blackbuck have smoother transition to core and bases rise more centrally over depressions for the supraorbital foramina.



Horn/antler shape: (Fig. C-3)

Deer and elk have antlers (usually forked except in immatures).

Sheep (top right) and goats (lower right and second from lower right) have unbranched horn sheaths with open curl or spiral and partially flattened cross section.

Blackbuck (third from right) have unbranched sheaths which spiral closely around a long axis and which are nearly round in cross section.

APPENDIX D Tooth Age Classes

This appendix gives the detailed descriptions of all 25 tooth eruption-and-wear classes. The photographic series of a mandible for each class (both radiograph and slanted top view) are provided to assist speedy entry into the lists of classes and to help confirm identification when determining the age of a specimen (Fig. D-1, pp. 164-167). A comparison of position and designation for deciduous and permanent teeth is also given (Fig. D-2, p. 168).

Mandibular characters are emphasized because lower jaws are the most common type of material available. The more complete the specimen, however, the more certain one can be that the determination is correct. Appendix D lists all teeth for every class, so it is almost always possible to define at least a range of classes even if the tooth material is incomplete. Especially with incomplete specimens, the supplementary comments on other kinds of skull characteristics (listed under "Other" for each class) can also be of value.

To assign an age to a specimen

1. *Compare specimen against key characteristics in Table 5-2, Chapter 5, or against the photographic series.*
2. *Evaluate specimen tooth by tooth using the Appendix D class description indicated by step 1.*
3. *Compare specimen with the Appendix D description of the next older class and the next younger class.*
4. *If one of the classes in step 3 is a better match, review the class following or the class preceding it as well.*
5. *Repeat step 4 until the best match is bracketed.*
6. *If mandibular material is involved, check it against the pictures of its class. Go back to the class descriptions to settle any doubts.*
7. *Note estimated age of class.*

CLASS I: birth

Incisiforms

i1 — oriented vertically; not fully erupted; hollow
i2 and i3 and c — partly out and all in line with i1

Mandible

pm2 — not visible; no alveolus for it
pm3 — partly erupted above bone and partly above gum
pm4[a] — partly erupted above bone and partly above gum
M1[b] — in bone; well formed; alveolus open over cusps 1 plus

Maxillary

c — fully developed and entire (no notches at neck)
pm2 — partly through bone and probably point through gum
pm3[c] — both cusps most of way through bone and probably points through gum
pm4 — partly through bone; points *may* or may not be through gum
M1[d] — in partly open alveolus but is only a (whole) papery shell

Other

Skull tiny and fragile; gap between frontals; interparietal sutures clear

---

[a]pm4 in the deciduous dentition is divided into three major lobes whereas in the permanent dentition pm4 has two.

[b]All the lower molars have two major lobes in both the deciduous and the permanent dentition. The anterior lobe has the metaconid bucally and the protoconid lingually (cusps 1) while the posterior lobe has the entoconid bucally and the hypoconid lingually (cusps 2). The paraconid is present but inconspicuous. When heavily worn, the hypoconid of mandibular M3 is large enough to give the tooth a three-lobed appearance.

[c]pm3 in the deciduous dentition has two lobes while Pm3 in the permanent dentition has one.

[d]The upper molars have two lobes in both the deciduous and the permanent dentition. The anterior lobe has the paracone bucally and the hypocone lingually (cusps 1) while the posterior lobe has the metacone bucally and the protocone lingually (cusps 2).

CLASS II: 1 week

Incisiforms

i1 — almost in place or with final orientation but not fully up
i2 and i3 and c — top edges still even but not fully up

Mandible

pm2 — alveolus open for it; barely above bone
pm3 — same as Class I
pm4 — above both bone and gum but not fully erupted
M1 — alveolus open for both cusps; level with top of bone; well formed

Maxillary

c — still well developed and without notches at neck
pm2 — main point definitely through gum; somewhat further erupted
pm3 — through bone and gum; a little further erupted
pm4 — cusps 1 through gum but cusps 2 may not be quite
M1 — level with bone in open alveolus; no further alveolus

Other

Skull larger but still fragile; sutures still not firmly joined; teeth still hollow

CLASS III: 2 weeks

Incisiforms

i1 — has attained final orientation; may or may not be fully erupted
i2 and i3 and c — same state of eruption as i1

Mandible

pm2 — same as Class II
pm3 — further erupted but not yet fully up
pm4 — further erupted but not yet fully up
M1 — cusps 1 and 2 beginning to come through bone (points) but not through gum

Maxillary

c — same as Class II
pm2 — well on way but not yet fully out
pm3 — noticeably farther out
pm4 — cusps 1 well through gum
— cusps 2 may not be quite through gum
M1 — points coming through bone; no further alveolus

Other

May or may not still be a gap between frontals; other sutures still well defined

CLASS IV: 3 weeks

Incisiforms

i1, i2 and i3 and c — fully up but no wear

Mandible

pm2 — not quite through gum to all of pointed crown through gum; straight sides not above bone yet
pm3 — further erupted; slight to light wear
pm4 — further erupted; slight to light wear
M1 — cusps 1 all to almost all above bone but probably not through gum
— cusps 2 points only through bone

Maxillary

c — same as Class III
pm2 — much farther erupted but not fully; no wear
pm3 — only slightly further erupted; slight to light wear
pm4 — cusps 1 well formed and more above gum now; slight to light wear
M1 — points farther through bone and points of cusps 1 may even penetrate gum

Other

All sutures closed; sutures between interparietals gone or fading; this class is first to show wear.

CLASS V: 1 month

Incisiforms

i1 — no wear; thicker now although still hollow
i2, i3 and c — no wear yet

Mandible

pm2 — rarely not quite through gum; straight sides coming through bone; no wear
pm3 — line-type wear on posterior slope but hardly any wear on anterior slope
pm4 — all cusps in wear (mostly light wear but rarely broadening); all infundibula intact; enamel not worn through everywhere on cusps between inner and outer
M1 — both cusps above gum; cusps in slight to light wear; cusps 2 not in wear
M2 — out of view in alveolus (papery shell); moderate hole in alveolus for it

Maxillary

c — same as Class IV
pm2 — edges still sharp and surface not flat but dentine exposed over about ½ of occlusal surface
pm3 — light wear on both cusps 1 and cusps 2
pm4 — light wear on cusps 1 and anterior slope of cusps 2
M1 — somewhat more than points just coming through open alveolus

Other

Interparietal sutures no longer visible; significant wear on cheek teeth.

CLASS VI: 2 months

Incisiforms

i1 — no wear; hollow gap almost gone
i2 and i3 and c — no wear yet

Mandible

pm2 — same as Class V
pm3 — slight wear often apparent on part to whole of anterior slope; moderate wear on posterior slope
pm4 — moderate wear (exposed dentine wider than enamel)
— cusps 1 infundibulum present to almost gone
M1 — cusps 1 light (or slight) wear
— cusps 2 above gum and usually without wear (occasionally with slight wear)
— secondary cusp* not yet above bone
M2 — visible down inside alveolus which has partial opening

Maxillary

c — entire to notched above, ½ through at neck
pm2 — occlusal all or nearly all worn almost flat; edges not sharp now
pm3 — moderate wear (dentine broad at level of center of cusps)
pm4 — same as pm3 except wear slight to light on posterior slope of cusps 2
M1 — cusps 1 above gum some; no wear
— cusps 2 coming out of opening alveolus

Other

Males have 3mm bumps (no sheath) where horns are forming.

*This secondary cusp is the hypoconulid. In older animals, the hypoconulid of M3 broadens with wear until it looks like a third lobe of the molar almost equal to the regular two lobes.

CLASS VII: 3 months

Incisiforms

i1 — light wear
i2 and i3 and c — same as Class VI

Mandible

pm2 — no wear to light wear
pm3 — dentine clearly evident on both anterior and posterior slope
pm4 — cusps 1 with or without infundibulum (or with it faintly)
M1 — cusps 1 in wear (light to moderate wear)
— cusps 2 has no wear to slight wear on anterior slope
M2 — forming inside alveolus (which has a small opening)

Maxillary

c — at least ⅓ notched to gone or broken off (always at least some evidence of socket)
pm2 — heavy wear (almost flat)
pm3 — moderate wear
pm4 — moderate (to flattish) wear
M1 — cusps 1 slight to moderate wear
— cusps 2 no wear but through bone and sometimes just coming through gum
M2 — forming inside alveolus

Other

Dentine broad and teeth now more robust (cheek teeth almost filled in); horns range from 7mm cores covered by bare "skin" to cores with horn sheaths of less than 50mm; upper canines never intact in this class.

CLASS VIII: 4 months

Incisiforms

i1 — light wear — I1 just forming inside alveolus
i2 — light wear
i3 and c — same as Class VII

Mandible

pm2 — no wear (to moderate wear)
pm3 — moderate wear on anterior slope and moderate to heavy wear on posterior slope
pm4 — cusps 1 wear moderate to heavy (with or without infundubulum)
— cusps 2 moderate wear to infundibulum tiny
— cusps 3 moderate wear
M1 — cusps 1 just through bone (no wear; not through gum)
— cusps 2 still in bone but points sometimes through holes in alveolus (or alveolus even open)

Maxillary

c — gone, but sockets often show
pm2 — same as Class VII
pm3 — moderate (to infundibulum shallow) to flattish wear
pm4 — moderate wear
M1 — cusps 1 light to moderate wear
— cusps 2 light to moderate wear on anterior slope and no wear on posterior slope
M2 — cusps 1 and 2 (points or whole tops of cusps) through bone but not gum; no further alveolus

Other

Horns always with a sheath but never any rings.

CLASS IX: 5 months

Incisiforms

i1 and i2 — light wear
i3 and c — same as Class VIII

Mandible

pm2 — no wear to moderate wear (fully up by now)
pm3 — anterior slope light to moderate wear; posterior slope moderate to heavy wear
pm4 — cusps 1 infundibulum gone (occasionally faint)
— cusps 2 and 3 moderate wear
M1 — cusps 1 moderate wear
— cusps 2 light to moderate wear (often less on posterior slope)
M2 — cusps 1 just through gum
— cusps 2 visible in alveolus (at least partly open) and may have points out
M3 — papery shell inside alveolus

Maxillary

c — trace of sockets (usually faint but sometimes fairly clear)
pm2 — same as Class VIII
pm3 — moderate wear approaching heavy (infundibulum shallow and tooth flattish)
pm4 — moderate wear
M1 — cusps 1 moderate wear
— cusps 2 light to moderate wear on anterior slope and none to light on posterior slope
M2 — cusps 1 and 2 just breaking through bone (cusp 1 is farther out)
M3 — cusps 1 are just beginning to form within small alveolus which is just formed

Other

Maximum horn development in this class has first clear ring that will be fairly complete just ready to start forming.

CLASS X: 6 months

Incisiforms

i1 — still in place — I1 formed (vertically) inside alveolus
i2 and i3 and c — still in place; no permanent equivalents visible in these sockets

Mandible

pm2 — light to heavy wear (sometimes gone or socket filling up)
pm3 — anterior slope moderate to heavy wear; posterior slope heavy wear; sometimes flattish
pm4 — cusps 1 infundibulum gone
— cusps 2 infundibulum trace or gone
— cusps 3 moderate to flattish wear with shallow infundibulum
M1 — moderate wear to cusps 1 sometimes flattish and cusps 2 moderate
M2 — cusps 1 with light wear on anterior slope but no wear on posterior slope
— cusps 2 through bone and points may be breaking through gum
— posterior style not yet through bone

Maxillary

c — same as Class IX
pm2 — same as Class IX
pm3 — flattish with infundibulum shallow; anterior infundibulum sometimes faint
pm4 — flattish wear
M1 — moderate wear
M2 — cusps 1 well through bone but not through gum (or just through gum)
— cusps 2 breaking bone to well up but not through gum

Other

Horns with first full ring just formed to horns with second full ring just formed.

CLASS XI: 8 months

Incisiforms

i1 — in place except in older individuals of this class who have lost it as I1 erupted half way — I1 vertically oriented within socket to ½ erupted with final orientations; tooth well formed
i2 and i3 and c — in place — I2 and I3 and C visible down inside sockets (all at about same level)

Mandible

pm2 — wear moderate to heavy (or nil where no occlusion with the maxillary teeth); sometimes broken at neck or gone without a trace
pm3 — posterior slope heavy wear and anterior slope moderate to heavy wear (thus sometimes flattish or almost flat)
pm4 — cusps 1 flat
— cusps 2 infundibulum tiny or gone (occasionally only shallow)
— cusps 3 flattish (rarely moderate) wear to infundibulum small or even gone
M1 — moderate (or flattish) wear
M2 — cusps 1 moderate or light anterior wear and light to no wear on posterior slope
— cusps 2 light or no wear anteriorly and no wear posteriorly
— secondary cusps show above bone
M3 — level with or just below bone; alveolus open to small holes only

Maxillary

c — sometimes traces but no sockets
pm2 — same as Class X
pm3 — cusps 1 flat with infundibulum shallow to lacking
— cusps 2 flat with infundibulum shallow
pm4 — flattish to flat
M1 — moderate to flattish wear
M2 — cusps 1 light wear anteriorly; light or no wear posteriorly
— cusps 2 through bone or gum but no wear
M3 — inside or just breaking out of alveolus (with at least a slit opening) but not through gum

Other

Horns do not spiral yet.

CLASS XII: 10 months

Incisiforms

I1 — just about to come out of socket (vertical) or partly into place
i1 and i2 and c — getting loose — I2 and I3 and C at or near opening of socket

Mandible

pm2 — heavy wear or gone and socket then also gone
pm3 — heavy wear (only shallow slope)
pm4 — cusps 1 no infundibulum
— cusps 2 no or tiny infundubulum
— cusps 3 flat with shallow or no infundibulum
M1 — moderate (to flattish) wear
M2 — cusps 1 moderate to light wear
— cusps 2 light wear anteriorly and no wear posteriorly
M3 — cusps 1 just coming through bone

Maxillary

c — no indication of socket
pm2 — flat (often worn to near neck)
pm3 — flat with infundibula shallow (cusps 1 may be missing infundibulum entirely)
pm4 — flattish with infundibula shallow
M1 — moderate wear
M2 — cusps 1 light wear
— cusps 2 no or light wear anteriorly; no wear posteriorly
M3 — through bone only or just ready to push through openings in socket

Other

Horns have started to spiral.

CLASS XIII: 11 months

Incisiforms

I1 — about ½ to fully in place
i2 — getting loose and sometimes has fallen out — I2 on edge of socket to fully erupted
i3 — getting loose and sometimes has fallen out — I3 on edge of socket to ¾ erupted (I2 sometimes fully in place before I3 starts up from edge of socket)
c — getting loose and sometimes has fallen out — C on edge of socket to ¾ erupted (C sometimes still at edge of socket when I3 ⅓ up but often state of I3 and C is equivalent)

Mandible

pm2 — top of roots (just connected) showing in sockets to socket open to socket filling (occasionally still present with heavy wear)
pm3 — heavy wear (sometimes almost flat) — Pm3 formed inside socket but usually not visible
pm4 — still solidly in place; flat with infundibulum sometimes by cusps 2 (tiny) and/or cusps 3 (shallow to tiny) — Pm4 inside socket and sometimes visible
M1 — moderate to flattish wear
M2 — cusps 1 moderate wear
— cusps 2 moderate to light wear (fully up)
M3 — cusps 1 with (no wear or) light wear anteriorly
— cusps 2 through bone to point just through gum
— secondary cusp not visible yet

Maxillary

pm2 — flat; worn to or near neck but still joined; sometimes missing — Pm2 fully formed inside socket (occasionally just coming through bone); occasionally visible below pm2
pm3 — flat with shallow infundibula; infundibulum may be gone by anterior cusps — Pm3 sometimes visible in socket but usually is up inside (fully formed)
pm4 — flattish
M1 — moderate wear
M2 — cusps 1 moderate wear
— cusps 2 light wear anteriorly; light to no wear posteriorly
M3 — well through bone but not through gum (or only point through gum)

Other

Much of tooth replacement well under way.

CLASS XIV: 1 year

Incisiforms

I1 — in place; slight to light wear
I2 — in place; no wear
I3 — usually all (or virtually all) erupted; occasionally only ½ up with i3 gone
c — gone or being pushed out by C — C usually at opening of socket but often ⅓ to even fully up

Mandible

pm2 — rarely present on one side (whole or as stub broken off at neck); usually socket in process of shrinking but otherwise socket filling or gone
pm3 — heavy wear; usually loose with Pm3 showing underneath even with bone — Pm3 has no wear even when pm3 gone
pm4 — infundibula (all three) gone; tooth usually loose (often broken and partly gone) with Pm4 showing below — Pm4 above bone; rarely has light wear
M1 — moderate (to flattish) wear
M2 — moderate wear
M3 — cusps 1 light to moderate wear anteriorly and no wear posteriorly
— cusps 2 usually through gum (but sometimes only points through); no wear except sometimes slight wear on anterior slope
— secondary cusp at or slightly above bone

Maxillary

pm2 — sometimes present with Pm2 usually visible beneath
pm3 — loose or gone; flat with shallow infundubula (infundubulum by cusps 1 may be gone) — Pm3 ½ erupted (partly through gum)
pm4 — flat with shallow infundibula (one or both anterior infundibula may be gone); sometimes pm4 gone and Pm4 well through gum but not fully up and no wear
M1 — moderate wear
M2 — cusps 1 moderate wear
— cusps 2 moderate or light wear but not fully erupted
M3 — cusps 1 through or about to pierce gum; no wear
— cusps 2 erupting through bone or point barely through gum; no wear

Other

This is oldest class with any males that can be mistaken for spikes ("large spikes").

CLASS XV: 2 years

Incisiforms

I1 — in place; light wear (to moderate wear)
I2 — in place
I3 — sometimes only ⅓ erupted but usually in place
c — occasionally c still in place and C just starting out of socket but usually C virtually completely up

Mandible

pm2 — occasionally broken piece of root (or even whole tooth) but usually socket smaller and/or filled in and often socket is gone
pm3 — gone except in a few cases — Pm3 partly to completely up with no to light wear
pm4 — usually pm4 gone — Pm4 eruption more advanced than Pm3; Pm4 partly to completely up with no to moderate wear

M1 — moderate wear
M2 — moderate wear
M3 — cusps 1 moderate wear anteriorly; moderate to light wear posteriorly
— cusps 2 no to light wear anteriorly; no wear posteriorly
— secondary cusp definitely above bone but not quite above gum; no wear

Maxillary

pm2 — gone — Pm2 ⅓ erupted without wear to fully erupted with moderate wear
pm3 — usually gone but if present is loose and has first or both infundibula usually gone — Pm3 ⅓ erupted without wear to fully erupted with moderate wear
pm4 — sometimes still present but loose; front ½ may be gone (rarely has infundibula) — Pm4 ½ erupted and without wear to fully erupted with moderate wear
M1 — moderate wear
M2 — moderate wear
M3 — cusps 1 slight to light (sometimes moderate) wear
— cusps 2 no wear (sometimes not quite above gum but otherwise up)

Other

This is youngest class with any three-twist males (only just barely three-twist).

CLASS XVI: 3 years

Incisiforms

I1 — light wear
I2 — no wear; root shorter than crown
I3 and C — fully in; neck approximatley in middle

Mandible

Pm3 — slight to light wear; fully in (or almost); infundibulum usually present
Pm4[a] — light to moderate wear; fully in (or almost); infundibulum often present
M1 — moderate to flattish wear (lingual crests usually sharp on both sides of lingual cusp); cusps 1 infundibulum rarely small to absent
M2 — moderate to flattish wear (lingual crests usually sharp on both sides of lingual cusp)
M3 — cusps 1 moderate wear anteriorly; moderate (sometimes light) wear posteriorly
— cusps 2 light wear (sometimes moderate anteriorly)
— secondary cusp above gum (often just); no wear

Maxillary

Pm2[b] — light to heavy wear; fully up
Pm3 — light to moderate wear
Pm4 — moderate (occasionally light) wear
M1 — moderate to flattish wear
M2 — moderate wear
M3 — cusps 1 moderate wear
— cusps 2 slight to light anteriorly; no wear to slight wear posteriorly

Other

This is the first class in which all members have lost all deciduous teeth; normally pm2 (mandibular) is shed before this stage is reached.

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[a]pm4 has three major lobes where Pm4 has two

[b]pm2 has two major lobes whereas Pm2 has one.

CLASS XVII: 4 years

Incisiforms

I1 — light to moderate wear
I2 and I3 and C — no wear to light wear

Mandible

Pm3 — light to moderate wear
Pm4 — light to moderate wear
M1 — moderate to flattish wear; cusps 1 infundibulum sometimes small
— cusps 2 infundibulum sometimes shallow
M2 — moderate to flattish wear
M2 — moderate to flattish wear
— secondary cusp has moderate wear (occasionally none)

Maxillary

Pm2 — (moderate to) heavy wear (heavy = flat)
Pm3 — moderate to flattish wear
Pm4 — moderate to flattish wear
M1 — moderate to flattish wear; infundibula always well defined
M2 — moderate to flattish wear; infundubula always well defined
M3 — cusps 1 moderate (sometimes heavy) wear
— cusps 2 light to moderate wear anteriorly; moderate to light wear posteriorly; infundibulum not quite enclosed; metastyle not quite evident (rarely just formed but ring still not quite closed)

Other

Horns of males normally three-twist or greater (unless spiral extremely open)

CLASS XVIII: 5 years

Incisiforms

I1 — light to moderate wear (rarely heavy but not flat and triangular)
I2 — moderate wear
I3 and C — moderate wear (although may be hard to see wear surface)

Mandibular

Pm3 — moderate to heavy wear but not flat; infundibulum usually present
Pm4 — moderate to heavy wear (often more than on Pm3) but not flat; "infundibulum"* is open on one side)
M1 — flat or flattish

— cusps 1 smooth or almost
— cusps 2 with infundibulum (clear but often shallow)

M2 — moderate to flattish wear (sometimes even flat); infundubula clear

M3 — moderate to flattish (but not flat)

Maxillary

Pm2 — flat; heavy wear (sometimes occlusal surface has a dark, unworn spot toward anterior, lingual surface)

Pm3 — flat or flattish wear but infundibulum usually clear

Pm4 — moderate to flattish wear; infundibulum still clear and usually not diminished in size

M1 — flattish or flat (occasionally moderate)

M2 — moderate to flattish wear (occasionally flat)

M3 — moderate to flattish (rarely one pair of cusps is flat but not both); cusps 2 usually with infundibulum enclosed
— metastyle (well developed whenever cusps 2 infundibulum enclosed) is not yet hook-shaped

Other

General aspect of maxillary wear is flattish and is similar to class XVII except that M3 cusps 2 infundibulum is well enclosed; Class XVIII is first in which I1 wear has sometimes broadened to form more than just a band along the edge.

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*See note 3, Table 5-2

CLASS XIX: 6 years

Incisiforms

I1 — usually heavy wear but sometimes moderate (rarely triangular and flat)

I2 — moderate to heavy wear

I3 — moderate to heavy wear (sometimes partly shielded by I2 and C); neck approximately in middle

C — usually heavy but sometimes moderate wear; neck near middle but shifting somewhat to one side or the other.

Mandible

Pm3 — smooth and flat; sometimes has open cavity of side ridges (infundibulum) and rarely has a true infundibulum; heavy wear

Pm4 — heavy wear; tooth smooth and flat; sometimes has "infundibulum" similar to Pm3 (rarely has a true infundibulum)

M1 — smooth and flat; heavy wear; occasionally small infundubulum between cusps 2

M2 — moderate to flattish wear; infundibula sometimes shallow

M3 — moderate to flattish wear
— secondary cusp with moderate to heavy wear

Maxillary

Pm2 — heavy wear; flat; not noticeably short yet

Pm3 — flattish wear with infundibulum small and sometimes shallow to flat; heavy wear

Pm4 — usually moderate to flattish wear with infundubula clear but sometimes smooth and flat

M1 — flattish to flat; all infundubula clear (left and right) to posterior infundibula only (occasionally not even one infundibulum left)

M2 — moderate to flattish wear with infundibula clear

M3 — moderate to flattish wear
— metastyle well developed and sometimes hook-shaped

Other

This is youngest class with hook-shaped metastyle on M3 (maxillary) and the youngest class in which a flat, triangular wear surface may (rarely) be developed on I1; zone of postmature growth common at horn bases.

CLASS XX: 7 years

Incisiforms

I1 — heavy wear to triangular and flat

I2 — moderate to heavy wear

I3 — moderate to heavy wear; neck can still be in middle

C — heavy wear; root somewhat longer than crown

Mandible

Pm3 — heavy wear; either with an infundubulum or flat

Pm4 — heavy wear; sometimes with an infundibulum (or trace of one) but largely flat

M1 — flat to concave

M2 — flat to flattish; cusps 1 infundibulum very shallow to tiny
— cusps 2 infundibulum clear but sometimes shallow

M3 — flattish wear (occasionally flat); infundibula clear but can be shallow
— secondary cusps large and heavily worn; is flat and forms a rather small tooth lobe without an infundibulum

Maxillary

Pm2 — heavy wear; flat but not noticeably short

Pm3 — heavy wear; flat; sometimes with small or tiny infundibulum and sometimes without

Pm4 — infundibulum clear but shallow

M1 — flat; infundibulum between cusps 1 always more worn than that between cusps 2
— cusps 1 infundibulum shallow to gone (usually gone, at least on one side and usually on both sides)
— cusps 2 infundibulum shallow to small

M2 — flattish; infundibula clear but shallow

M3 — moderate to flattish

Other

I1 wear heavy probably still predominates over I1 wear triangular and flat; horns always with zone of postmature growth at base.

CLASS XXI: 8 years

Incisiforms

I1 — triangular and flat (sometimes just heavy wear)
I2 and I3 — heavy wear
C — heavy wear; crown shorter than root

Mandible

Pm3 — heavy wear; flat and smooth; sometimes with an "infundibulum" on side
Pm4 — heavy wear; flat and smooth
M1 — heavy wear; flat and smooth (to concave); can be so worn that roots show or tooth even worn apart with stub of anterior root and cusps 2 sheared off alone
M2 — flattish to flat; cusps 1 smooth; may be a small infundibulum on one side
— cusps 2 infundibulum shallow but always present
M3 — flattish to flat (rarely moderate wear); tooth shape well defined; infundibula clear and usually shallow (sometimes cusps 1 infundibulum small)

Maxillary

Pm2 — heavy wear; flat and smooth; occasionally worn to near neck
Pm3 — heavy wear; flat and smooth; occasionally worn to near neck; sometimes with a tiny infundibulum
Pm4 — flattish to flat; infundibulum fully developed to shallow (usually) even to gone on one side
M1 — flat; cusps 1 infundibulum sometimes shallow but usually small or gone on one or both sides
— cusps 2 infundibulum shallow to small or even gone but rarely gone on both sides
M2 — flat to flattish; infundibulum clear
M3 — flat to flattish
— metastyle well developed and usually like a knob or hook

Other

Curve of bone from posterior end of maxillary tooth row toward midline sometimes maximally flat; wear becoming noticeably uneven in some members of this class.

CLASS XXII: 9 years

Incisiforms

I1 and I2 and I3 — same as Class XXI
C — heavy wear

Mandible

Pm3 — heavy wear; flat and smooth; can be worn to stubs; no infundibula
Pm4 — heavy wear; flat or concave and smooth; can be worn to stubs (juncture between roots sometimes gone)
M1 — smooth and sometimes concave; can be worn to roots (or close) on anterior lobe or both lobes
M2 — smooth or with small to trace infundibulum between cusps 2 of M2 left or M2 right; occasionally concave on one side if wear uneven
M3 — flattish or flat; cusps 1 with shallow infundibulum or shallow on one side and small or even lacking in other jaw
— cusps 2 infundibulum shallow

Maxillary

Pm2 — flat and smooth; sometimes worn to near roots
Pm3 — flat and smooth; sometimes worn to near roots (roots still joined)
Pm4 — wear often uneven; moderate to flattish wear to smooth and uneven; infundibulum well developed to shallow to gone
M1 — smooth to small infundibulum between one or both posterior pairs of cusps
M2 — flat with shallow infundibula
M3 — flattish to flat
— metastyle well developed (often hooked)

CLASS XXIII: 10-11 years

Incisiforms

I1 — same; when wear surface triangular and flat, neck can be almost ⅓ nearer tip of crown than tip of root
I2 — heavy wear; when I1 triangular and flat, crown about ⅓ as long as root
I3 and C — heavy wear; crown becoming short but root is short as well

Mandible

Pm3 — heavy wear (sometimes to roots but these are still joined); flat and smooth; occasionally a small partial "infundibulum" on one side
Pm4 — heavy wear; flat and smooth; occasionally a small infundibulum on one side
M1 — smooth; flat to concave; sometimes worn to near neck on one side but roots still joined
M2 — smooth and not concave; occasionally an infundibulum between one pair of cusps 2 but not full size
M3 — flat or sometimes flattish; cusps 1 worn smooth with sometimes a small to trace infundibulum on one side
— cusps 2 with shallow (sometimes small on one side) infundibulum; occasionally infundibulum gone on one side

Maxillary

Pm2 — heavy wear; flat; often worn to neck
Pm3 — heavy wear; flat; often worn to neck
Pm4 — heavy wear usually; flat and can be worn to near neck (roots barely joined); occasionally flattish with shallow infundibulum on one side and flat with small infundibulum on other side

M1 — heavy wear; smooth; roots still joined
M2 — flat with infundibula shallow; sometimes infundibula round or gone on one side or on anterior cusps
M3 — flattish to flat with infundibula well developed to shallow
— metastyle well developed and often hooked

Other

Wear uneven but only one or two teeth (Pm4, M1) or no teeth worn to stubs (mandible)

CLASS XXIV: 12-13 years

Incisiforms

I1 — heavy wear to triangular and flat
I2 — heavy wear
I3 — heavy wear; crown often short
C — heavy wear; crown short

Mandible

Pm3 — heavy wear; flat to worn to stubs (roots may or may not be joined)
Pm4 — heavy wear; flat to worn to stubs (roots may or may not be joined)
M1 — heavy wear; flat to worn to stubs (roots may or may not be joined); sometimes socket very shallow
M2 — heavy wear; flat to worn to stubs (roots may or may not be joined)
M3 — heavy wear; tooth slopes forward but shape is still well defined; smooth or small infundibulum between cusps 2

Maxillary

Pm2 — heavy wear; flat; often worn to neck of tooth and small
Pm3 — heavy wear; flat; sometimes tiny infundibulum on each side; occasionally Pm3 on one side worn to near neck (roots still joined)
Pm4 — flattish with shallow infundibulum on one or both sides or smooth and flat on one or both sides
M1 — flat and smooth; worn low near neck and sometimes broken into two or three pieces (occasionally a piece is gone and its part of socket is filling in)
M2 — heavy wear; flat; cusps 1 infundibulum shallow, small or cusps 1 worn smooth (either same on both sides or not)
— cusps 2 infundibulum shallow, small or cusps 2 worn smooth (both sides may or may not match)
— any, but never all, of the four infundibula (cusps 1 left and right, cusps 2 left and right) may be gone
M3 — heavy wear; flat; tooth sometimes with shape not clearly defined (occlusal view); occasionally M3 is only bulbous stubs (cusps 1 not joined to rest) in shallow sockets
— cusps 1 infundibulum shallow, small or gone (usually both sides match)
— cusps 2 infundibulum shallow (sometimes gone on one side)
— posterior metastyle well developed and often hooked

CLASS XXV: 14-16 years

Incisiforms

I1 — triangular and flat wear surface
I2 — heavy wear; often wedge shaped
I3 — heavy wear; often crown short
C — crown short but root often even shorter; occasionally only a stub

Mandible

Pm3 — wolf-like on one or both sides or else worn to neck (roots still joined)
Pm4 — worn to near roots (may or may not be joined)
M1 — worn to stubs (usually not joined); sometimes gone and sockets filled in on one side
M2 — worn to stubs (occasionally not quite to neck on one side); stubs joined or not (often joined on one side but not on other)
M3 — shape not clearly defined (occlusal view); anterior lobe often worn to stubs (roots usually joined but occasionally not)
— posterior lobe worn to or near neck but root marks do not show; occasionally a tiny infundibulum on one side
— secondary cusp like a third lobe; smooth; heavy wear; occlusal surface even with that of posterior lobe or below it

Maxillary

Pm2 — heavy wear; flat; sometimes worn to near neck
Pm3 — heavy wear; flat; smooth or with small infundibulum (both sides); sometimes worn to stubs on one side (roots joined)
Pm4 — heavy wear; flat; infundibulum shallow (or sometimes gone on one side)
M1 — heavy wear; flat; anterior lobe smooth at least on one side (other side with small indundibulum or seldom with shallow infundibulum of not smooth); if smooth, roots sometimes show on occlusal surface
— cusps 2 shallow infundibulum, small or smooth (usually both sides match)
M2 — heavy wear; flat; all infundibula shallow to posterior infundibula gone; alternatively, infundibula shallow on one side and small on other (both lobes) or shallow on one side and gone on other (both lobes)
M3 — heavy wear; flat; shape not well defined; wear on same side more alike than wear on same cusps; cusps 1 infundibulum small or gone
— cusps 2 infundibulum small or gone
— metastyle is a well devleoped, backward projection

Other

Curve of bone from posterior end of maxillary tooth row toward midline usually maximally flat; sockets for missing mandibular cheek teeth have filled.

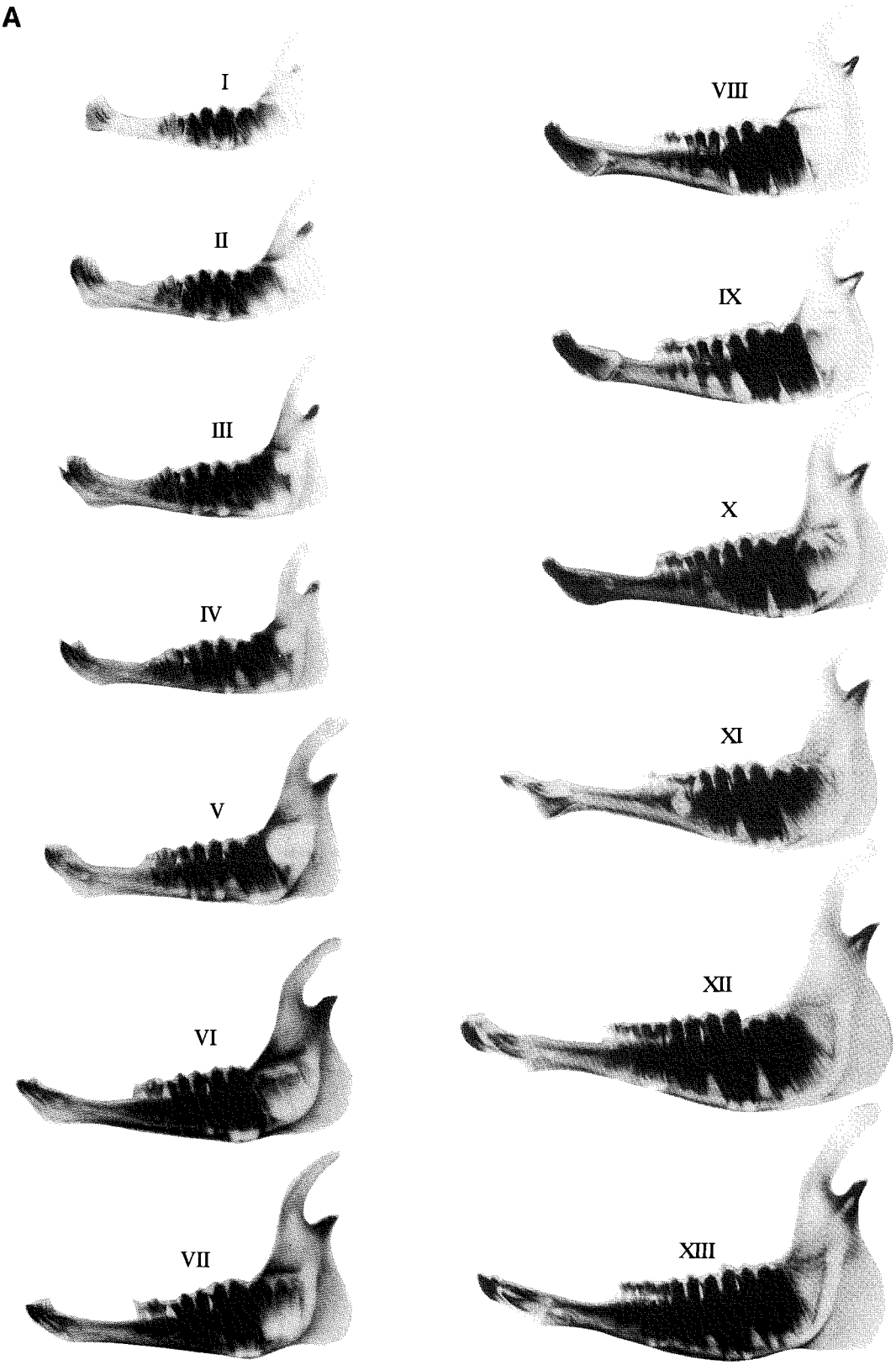
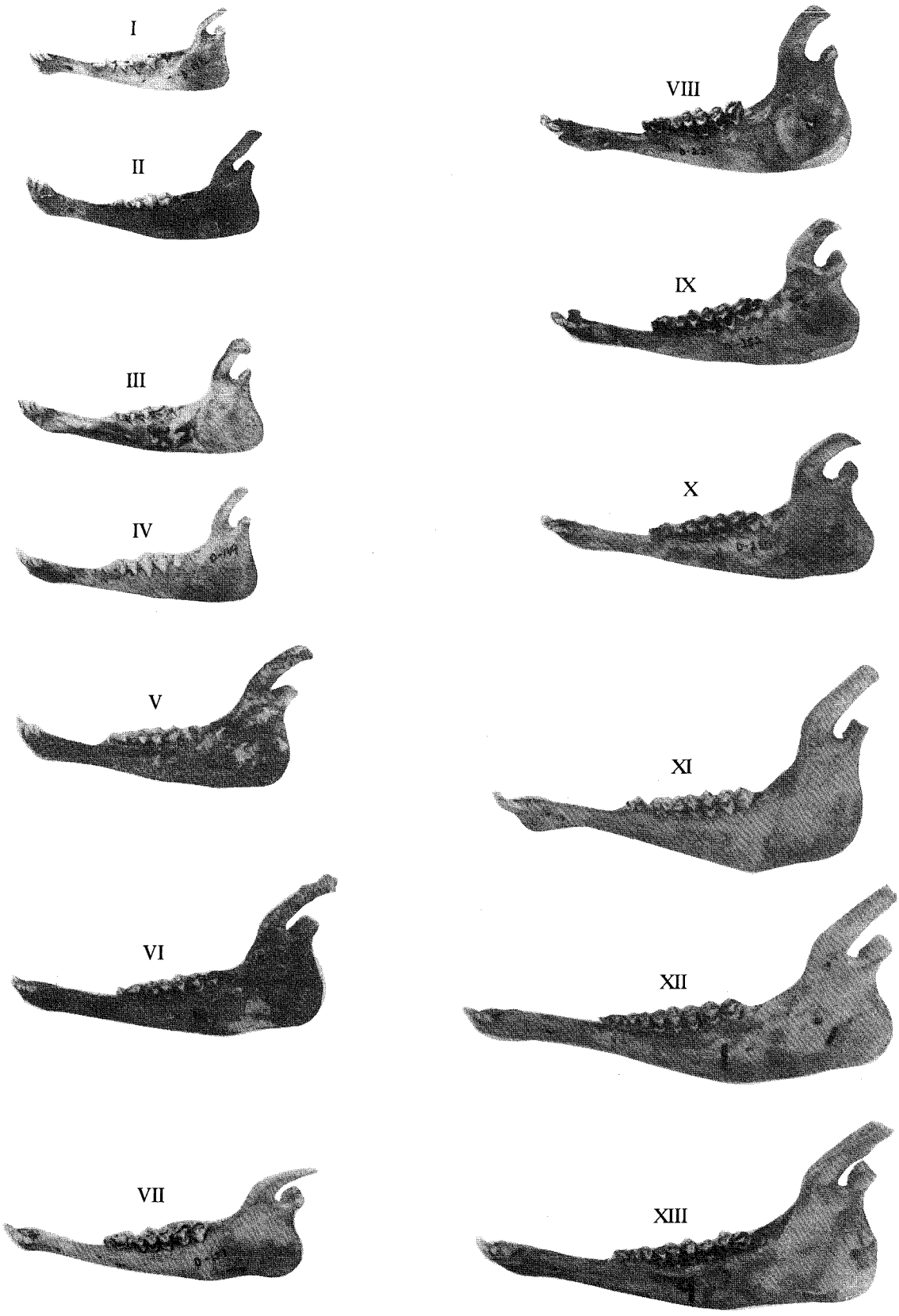
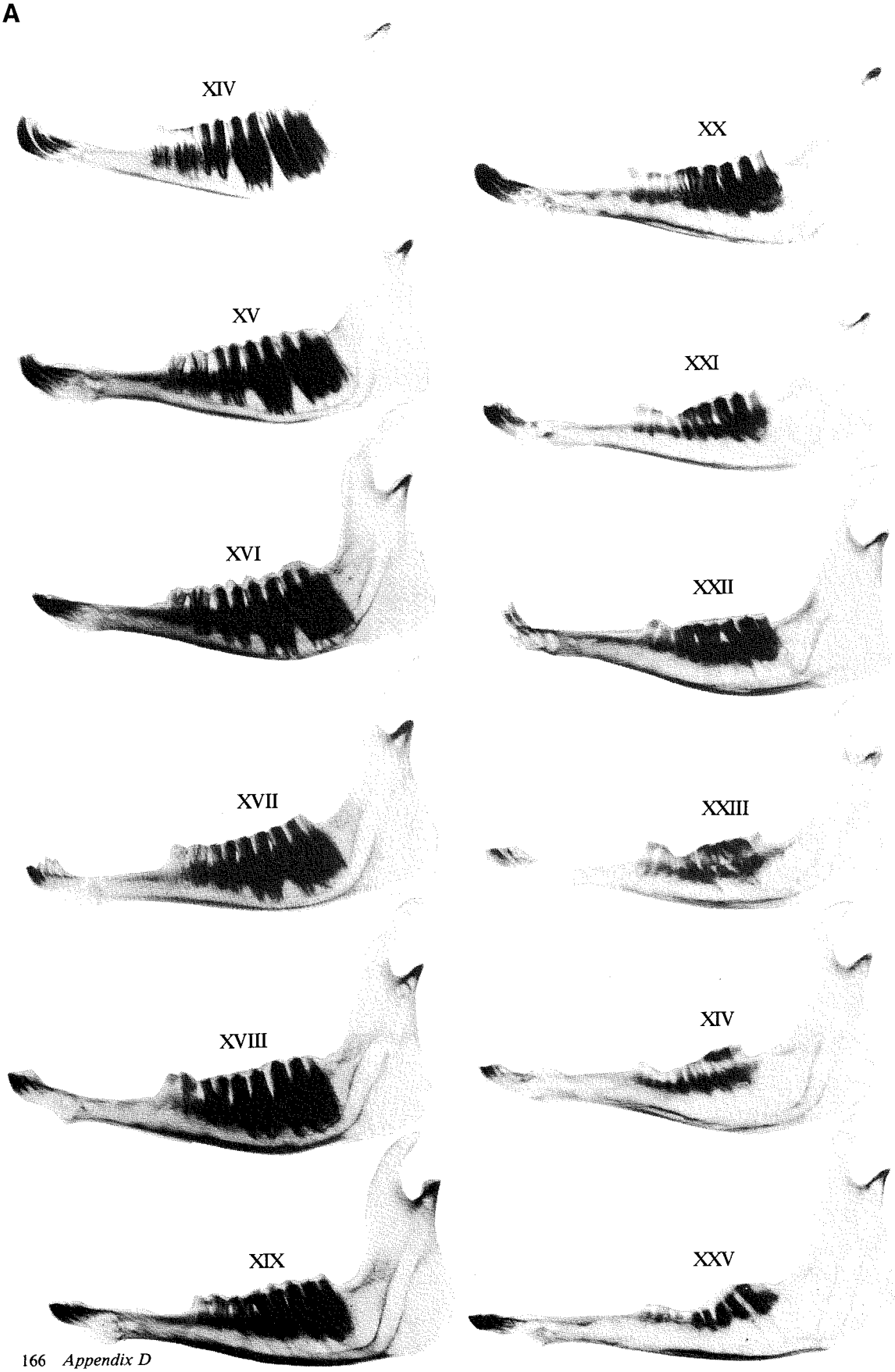


FIG. D-1. Eruption-and-wear classes illustrated by one left mandible from each class: (A) radiograph, here and on p. 166, and (B) slanted top view, pp. 165 and 167. (Roman numeral gives number of class.)

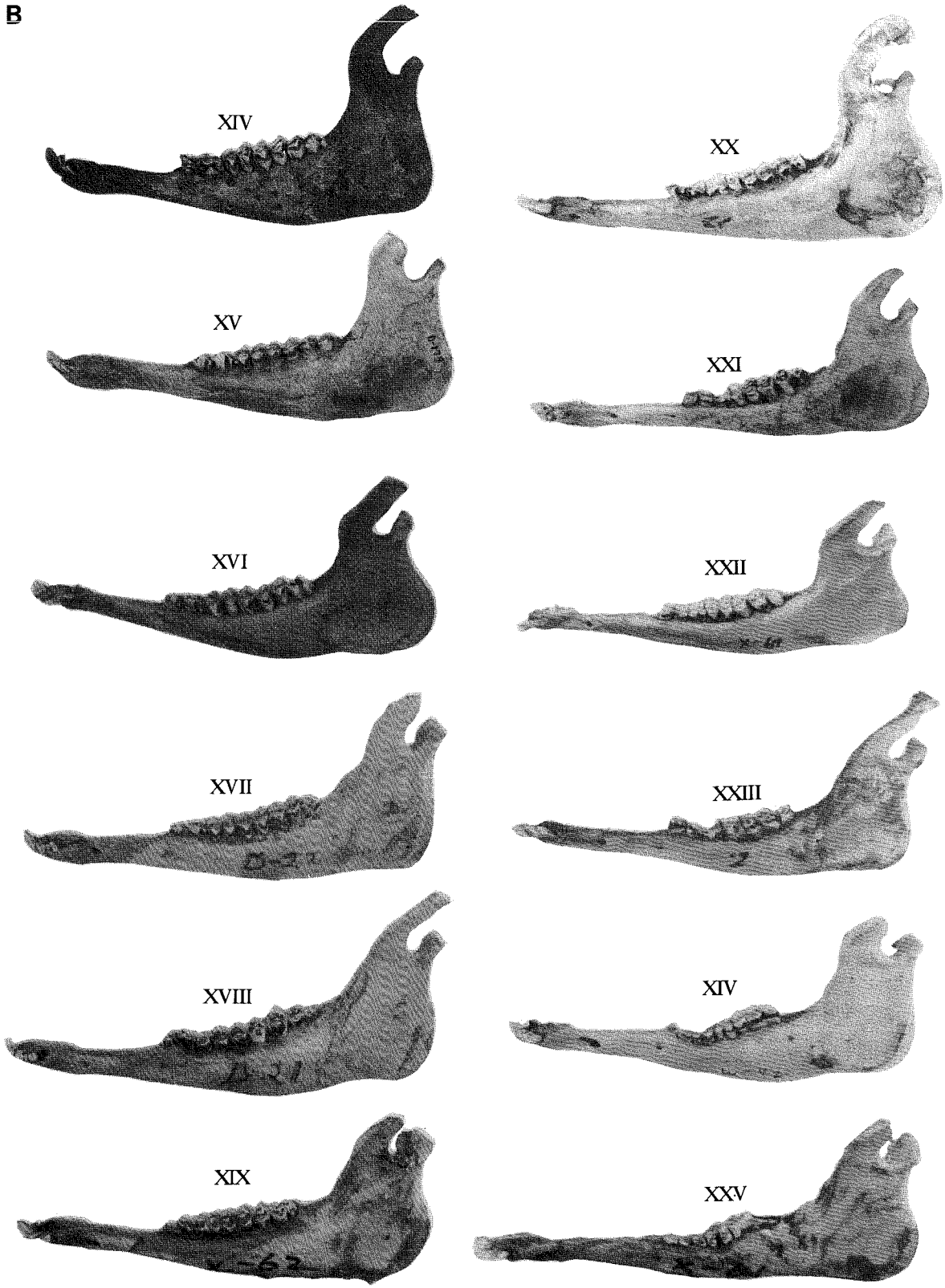
B



A



B



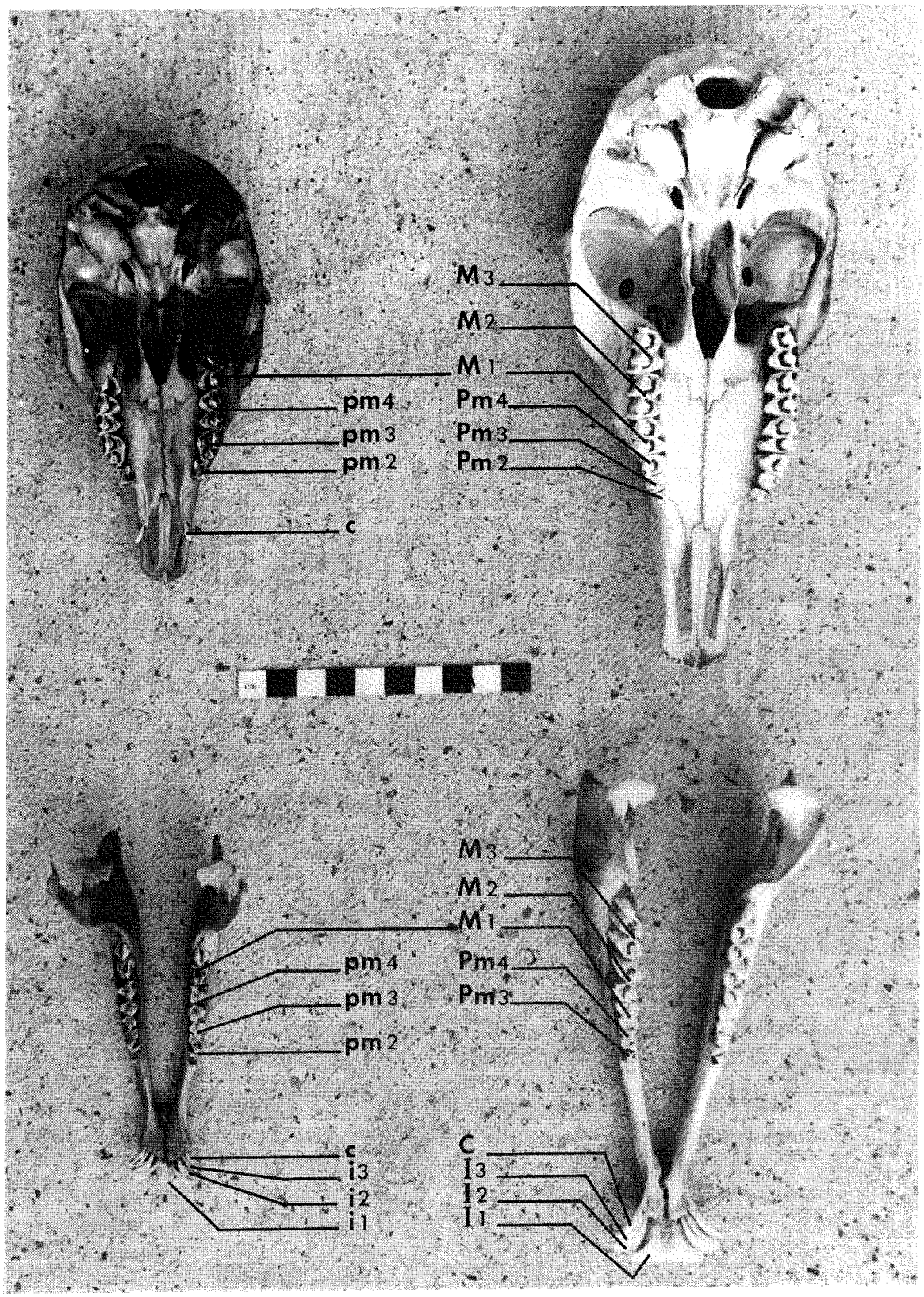


FIG. D-2. Comparison of position and designation for deciduous (left) and permanent teeth.

APPENDIX E Common Names

Considering India's wealth of native languages, it is no surprise that numerous different names have been applied to the blackbuck in various parts of its native distributional area. Note, however, how many of the names fall into groups.

Name	(♂only)	(♀only)	Language or Locality	Reported by
Krishnasara			Sanscrit	Dharmakumarsinhji and Gaikwad 1958
	Ena		"	Blanford 1888-91 Lydekker 1907 Prater 1971
Harina			"	Blanford 1888-91 Lydekker 1907
		Harina	"	Prater 1971
Mirga[1]			Sanscrit[2]	Jerdon 1874 Blanford 1888-91 Lydekker 1907 Prater c. 1948[1] Sterndale 1884
Mirug (derivative of *Mirga*)			from Sanscrit	Percy 1894
	Mirga		of some Hindustanis	Jerdon 1874
Mrig[2]			Hindu[2]	Blanford 1888-91 Lydekker 1907 Prater 1971
Haran[3]			"	Blanford 1888-91 Brander 1923 Prater 1971
	Haran		Hindi and generally in India (also Mahrathi)	Jerdon 1874 Lydekker 1907
	Harna		Hindi	Sterndale 1884 Blanford 1888-91 Lydekker 1907 Prater 1971
		Harna	of some Hindustanis	Jerdon 1874
		Harni	Hindi	Blanford 1888-91 Lydekker 1907 Brander 1923 Prater 1971
Hirun			"	Sterndale 1884
		Hirni	"	Sterndale 1884
	Harnin		"	Sterndale 1884
		Harnin	Hindi and generally in India (also Mahrathi)	Jerdon 1874
Kalwit (= the black buck)			Hindi	Jerdon 1874
		Kalwit	"	Blanford 1888-91 Lydekker 1907 Prater 1971

[1]*Mriga* as listed in Prater (1971) seems to be a misprint for *mirga*.
[2]Sterndale (1884) gives *mrig* along with *mirga* as being Sanscrit.
[3]Of the Indian vernacular names, *haran* or related forms are probably the most commonly used in English accounts. Sterndale (1884) lists *harna, hirun, harin* (male) and *hirni* (female). Percy (1894) gives the spelling *heran*, and Aflalo (1904) gives *hiran*.

(Continued on next page)

Name	(♂ only)	(♀ only)	Language or Locality	Reported by
Kālā hiran[4] (= black deer)			〃	Bābur 1922 Brander 1923 Ali 1927
Kalhāreh[4] (probably a corruption of *kālā hiran)*			〃	Bābur 1922 Ali 1927
	Haran		Mahrathi (also Hindi and generally in India)	Jerdon 1874 Prater 1971
		Harnin	〃	Jerdon 1874
Hiru			Mahrathi	Sterndale 1884
	Kalwit		〃	Prater 1971
Phandayat[5] (= the black buck)			Mahrathi	Jerdon 1874 Blanford 1888-91 Lydekker 1907
Bamuni-hiru			〃	Sterndale 1884
Bāmani-haran			Mahrathi (also Uria)	Blanford 1888-91 Lydekker 1907
Bāmani-haran			Uria (also Mahrathi)	Blanford 1888-91 Lydekker 1907
Harin			in Bengal	Jerdon 1874
		Pulvaai	Tamil	Krishnan 1972
Veli-man			〃	Blanford 1888-91 Lydekker 1907
Moorukoo marn[6]			〃	Prater 1971
Kalai-maan			〃	Krishnan 1972
	Kalai		〃	Krishnan 1972
	Alali		Baori	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
		Gandoli	〃	Sterndale 1884
	Kālā		in Tirhoot	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
Guria			〃	Jerdon 1874
Goria			〃	Jerdon 1874
		Goria	〃	Sterndale 1884 Blanford 1888-91 Lydekker 1907
		Baoti	in Behar	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
	Kālsar		〃	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
	Kutsar		Korku	Blanford 1888-91 Lydekker 1907 Brander 1923

[4]The 16th century Indian emperor Bābur records that *kālā-haran* (or *kālā hiran*) is probably the original form which has become the Hindi name *kalahara* (or *kalhāreh*) by a softening in pronunciation (Bābur 1922, Ali 1927). When reading or translating Indian works, one must remember that Indian languages have no terms equivalent to the English words "antelopes" or "deer"; instead, the animals designated by these two words are all grouped under a single term (Krishnan 1972). Thus, *kālā hiran* can be translated "black deer," "black antelope" or "black buck." This often adds confusion to published translations.

[5]Sterndale (1884) spells this *"Phandayet."*

[6]This name is not in Prater c. 1948. Krishnan (1972) says that it should be discounted entirely because it is not a valid name for the blackbuck.

Name	(♂only)	(♀only)	Language or Locality	Reported by
Húlé-kara			Canarese	Blanford 1888-91 Lydekker 1907
Hoola kerra			"	Prater 1971
Chigri			"	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907 Prater 1971
Jinka (generic name)			Telegu	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907 Prater 1971
Ledi			"	Jerdon 1874 Blanford 1888-91 Lydekker 1907 Prater 1971
		Ledi	"	Jerdon 1874
		Sedi	"	Sterndale 1884
	Irri		"	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
Bádú			Ho Kol	Blanford 1888-91 Lydekker 1907
Buréta			in Bhágalpur	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907
Barout			Nepalese	Jerdon 1874 Sterndale 1884
Bárant			"	Blanford 1888-91 Lydekker 1907
Sásin			"	Jerdon 1874 Sterndale 1884 Blanford 1888-91 Lydekker 1907

APPENDIX F Food Plants

These plants have been recorded as eaten by blackbuck on the Indian subcontinent (O) or in Texas (X). The observations of native food habits come from both India and Pakistan. This list cannot include all food plants utilized by blackbuck, however, because comprehensive data are not available from all areas

Common Name[1]	Scientific Name[1]	Reported by	India	Texas
GRASS-SEDGE				
	Aeluropus lagopoides	Daniel 1967	?	
Big bluestem	*Andropogon gerardii*	Kerr Area study[2]		X
	Apluda varia	Dharmakumarsinhji 1967	0	
Lamb	*Aristida depressa*	Mirza and Waiz 1973	0	
Purple threeawn	*A. purpurea*	Kerr Area study		X
Lampdi	*A. redacta*	Dharmakumarsinhji 1967	0	
Wright threeawn	*A. wrightii*	Kerr Area study		?
Cane bluestem	*Bothriochloa barbinodis* var. *barbinodis*	Kerr Area study		X
Pinhole bluestem	*B. barbinodis* var. *perforata*	Kerr Area study		X
	B. odorata	Schaller 1967	0	
Sideoats grama	*Bouteloua curtipendula* var. *curtipendula*	Kerr Area study		X
Hairy grama	*B. hirsuta*	Kerr Area study		X
Texas grama	*B. rigidista*	Kerr Area study		X
Red grama	*B. trifida*	Kerr Area study		X
Nealley grama	*B. uniflora*	Kerr Area study		X
Rescuegrass	*Bromus unioloides*	Kerr Area study		X
Carex, nutgrass	*Carex* sp.	Kerr Area study		X
Dhaman	*Cenchrus pennisetiformis*	Mirza and Waiz 1973	0	
Darup	*Chrysopogon fulvus*	Schaller 1967	0	
Khawai	*Cymbopogon jawarancusa*	Mirza and Waiz 1973	0	
Katran, Rons, Ronsado	*C. martinii*	Mirza and Waiz 1973	0	
	Cyperus arenarius	Daniel 1967	?	
Ghandeel	*Eleusine flagillifera*	Mirza and Waiz 1973	0	
Stinkgrass	*Eragrostis cilianensis*	Kerr Area study		X
Plains lovegrass	*E. intermedia*	Kerr Area study		X
Texas cupgrass	*Eriochloa sericea*	Kerr Area study		X
Hairy tridens	*Erioneuron pilosum*	Kerr Area study		X
Cagordio, dabshalio (smaller), serda	*Heteropogon contortus*	Schaller 1967	0	
Common curlymesquite	*Hilaria belangeri*	Kerr Area study		X
Gorkha	*Lasiurus hirsutus*	Bokhari 1970	0	
		Mirza and Waiz 1973	0	
Fall witchgrass	*Leptoloma cognatum*	Kerr Area study		X
Ozarkgrass	*Limnodea arkansana*	Kerr Area study		X
Murat	*Panicum antidotale*	Mirza and Waiz 1973	0	
Hall's panicum	*P. hallii*	Kerr Area study		X
Vine-mesquite	*P. obtusum*	Kerr Area study		X
Scribner panicum	*P. oligosanthes* var. *scribnerianum*	Kerr Area study		X
Annual bluegrass	*Poa annua*	Kerr Area study		X
Tumblegrass	*Schedonnardus paniculatus*	Kerr Area study		X

[1] Scientific names for the Indian plants follow the authors cited as do the common names from Krishnan (1972) and Mirza and Waiz (1973). All other common names of Indian plants are from Spillett (1968) and Berwick (1974). Where authors do not specify the forage classes to which species belong, this information has been checked in Hooker (1872-97).
Scientific names for the Texas plants follow Gould (1969) except for *Scrophularia* which is from a specimen in the herbarium set up by Gould at the Kerr Wildlife Management Area. Common names of all Texas plants are taken from Cary *et al.* (1975) which uses Gould (1969) as primary authority.

[2] The listing for the plants seen eaten during the bite study at the Kerr Wildlife Management Area is from Cary *et al* (1975). Kerr Area plant data is used courtesy of the Texas Parks and Wildlife Department. These data were gathered during investigations carried out under Pittman-Robertson Project (Federal Aid) W-76-R, Kerr Wildlife Management Area Research.

Common Name[1]	Scientific Name[1]	Reported by	India	Texas
Little bluestem	*Schizachyrium scoparium* var. *frequens*	Kerr Area study		X
Yellow Indiangrass	*Sorghastrum nutans*	Kerr Area study		X
Tall dropseed	*Sporobolus asper* var. *asper*	Kerr Area study		X
Meadow dropseed	*S. asper* var. *hookeri*	Kerr Area study		X
Texas wintergrass	*Stipa leucotricha*	Kerr Area study		X
	Themeda triandra	Schaller 1967	0	
Slim tridens	*Tridens muticus* var. *muticus*	Kerr Area study		X
	Vetiveria zizanioides	Schaller 1967	0	
FORB-VINE[3]				
Indianmallow	*Abutilon incanum*	Kerr Area study		X
Lindheimer copperleaf	*Acalypha lindheimeri*	Kerr Area study		X
Tenpetal anemone	*Anemone decapetala* var. *heterophylla*	Kerr Area study		X
White pricklepoppy	*Argemone albiflora* var. *texana*	Cary 1976a		X
Low wildmercury	*Argythamnia humilis* var. *humilis*	Kerr Area study		X
Bael fruit		Krishnan 1972	0	
Prairie bishop	*Bifora americana*	Kerr Area study		X
Twoleaf senna	*Cassia roemeriana*	Kerr Area study		X
Chickweed	*Cerastium* sp.	Kerr Area study		X
Hairyfruit chervil	*Chaerophyllum tainturieri* var. *dasycarpum*	Kerr Area study		X
Leastdaisy	*Chaetopappa* sp.	Kerr Area study		X
Carolina snailseed	*Cocculus carolinus*	Kerr Area study		X
Erect dayflower	*Commelina erecta* var. *erecta*	Kerr Area study		X
Oneseed croton	*Croton monanthogynus*	Kerr Area study		X
	family: Cucurbitacea spp.	Krishnan 1972	0	
Wild carrot	*Daucus carota?*	Kerr Area study		X
Larkspur	*Delphinium* sp.	Kerr Area study		X
Velvet bundleflower	*Desmanthus velutinus*	Kerr Area study		X
Khiri	*Euphorbia prostrata*[4]	Mirza and Waiz 1973	0	
Mat euphorbia	*E. serpens*	Kerr Area study		X
Rabbit tobacco, bighead evax	*Evax prolifera*	Kerr Area study		X
Bedstraw	*Galium* sp.	Kerr Area study		X
Drummond hedeoma	*Hedeoma drummondii* var. *drummondii*	Kerr Area study		X
Common sunflower	*Helianthus annus* var. *annus*	Cary 1976a		X
Whorled nodviolet	*Hybanthus verticillatus*	Kerr Area study		X
Chalkhill woolywhite	*Hymenopappus tenuifolius*	Kerr Area study		X
	Ipomoea spp.	Krishnan 1972	0	
Wild lettuce	*Lactuca* sp.	Kerr Area study		X
Bladderpod	*Lesquerella* sp.	Kerr Area study		X
Texas bluebonnet	*Lupinus texensis*	Kerr Area study		X
Burclover	*Medicago hispida*	Kerr Area study		X
Four-o'clock	*Mirabilis albida?*	Kerr Area study		X
Wild four-o'clock	*M. nyctaginea*	Kerr Area study		X
Phel	*Neslia* sp.	Mirza and Waiz 1973	0	
Evening primrose	*Oenothera* sp.	Kerr Area study		X
Yellow woodsorrel	*Oxalis dillenii* var. *dillenii*	Kerr Area study		X

[3] Dharmakumarsinhji's (1967) captive study would have yielded more records of forb use if rapid growth of the pungent, unpalatable *Ocimum basilicum* shoots during the monsoon had not covered other young plants.

[4] Hooker (1872-97) comments that this is an American species also native to West Africa and Mauritius but that he could not confirm Engelmann's statement that it occurs in India; instead, the Indian species referred to by Engelmann is probably *Euphorbia clarkeana*.

(Continued on next page)

Common Name[1]	Scientific Name[1]	Reported by	India	Texas
FORB-VINE (CON'T.)				
Pennsylvania pellitory	*Parietaria pennsylvanica* var. *pennsylvanica*	Kerr Area study		X
Perianthus		Kerr Area study		X
Knotweed leafflower	*Phyllanthus polygonoides*	Kerr Area study		X
Cutleaf groundcherry	*Physalis angulata* var. *lanceifolia*	Kerr Area study		X
Redseed plantain	*Plantago rhodosperma*	Kerr Area study		X
Mealycup sage	*Salvia farinacea* var. *farinacea*	Kerr Area study		X
Lanceleaf sage	*S. reflexa*	Kerr Area study		X
Green lily, Drummond sabadilla	*Schoenocaulon drummondii*	Kerr Area study		X
Figwort	*Schrophularia stemodia?*	Kerr Area study		X
Drummond skullcap	*Scutellaria drummondii*	Kerr Area study		X
Arrowleaf sida	*Sida rhombifolia*	Kerr Area study		X
Blue-eyegrass	*Sisyrinchium* sp.	Kerr Area study		X
Saw greenbriar	*Smilax bona-nox*	Kerr Area study		X
Texas stillingia	*Stillingia texana*	Kerr Area study		X
Spiderwort	*Tradescantia* sp.	Kerr Area study		X
Catnip noseburn	*Tragia nepetaefolia*	Kerr Area study		X
	Trianthema crystallina	Mirza and Waiz 1973	0	
Lambs lettuce, hairy cornsalad	*Valerianella amarella*	Kerr Area study		X
Upright verbena	*Verbena* sp.	Kerr Area study		X
Texas vetch, narrowleaf vetch	*Vicia angustifolia*	Kerr Area study		X
Wild bitter-gourd		Krishnan 1972	0	
Texas yucca, twistedleaf yucca	*Yucca rupicola*	Kerr Area study		X
Eveningstar rainlily	*Zephyranthes drummondi*	Kerr Area study		X
Orange zexmenia	*Zexmenia hispida*	Kerr Area study		X
TREE-BUSH				
	Acacia arabica	Dharmakumarsinhji 1967	0	
Khair	*A. catechu*	Berwick 1974	0	
Harmo	*A. leucophloea*	Dharmakumarsinhji 1967	0	
		Berwick 1974	0	
Bawal	*A. nilotica*	Berwick 1974	0	
		Oza 1976	0	
Gorad	*A. senegal*	Dharmakumarsinhji 1967	0	
Axlewood, dindaga, dindal, bejjalu, dhavdo, namai	*Anogeissus latifolia*	Berwick 1974	0	
Limdo, neem	*Azadirachta indica*	Berwick 1974	0	
Ingor	*Balanites aegyptiaca*	Berwick 1974	0	
		Oza 1976	0	
Asundro, basavan apuda	*Bauhinia racemosa*	Berwick 1974	0	
Salerdi	*Boswellia serrata*	Berwick 1974	0	
	Caesalpinia coriaria	Dharmakumarsinhji 1967	0	
Ak	*Callotropis* sp.[5]	Mirza and Waiz 1973	0	
	Capparis aphylla	Dharmakumarsinhji 1967	0	
Dele	*C. decidua*	Mirza and Waiz 1973	0	
		Oza 1976	0	
	Carissa carandas	Dharmakumarsinhji 1967	0	
Awal	*Cassia auriculata*	Oza 1976	0	
Kuwadia	*C. tora*	Oza 1976	0	
Hackberry	*Celtis* sp.	Kerr Area study		X
Chag	*Crotalaria burhia*	Mirza and Waiz 1973	0	
Rosewood, beete, eetti, shisham[6]	*Dalbergia latifolia*	Berwick 1974	0	

[5] Hooker (1872-97) spells the genus name *Calotropis*.

[6] Note that while Berwick (1974) gives *Dalbergia latifolia* the name "shisham" and *D. sissoo* the name "sissoo," Mirza and Waiz (1973) give the name "sheesham" to *D. latifolia*. Whether this is a case of common usage not distinguishing between similar species is unclear.

[7] *Dicrostonyx cinera* may be a synonym of *Dichrostachys cinerea*

Common Name[1]	Scientific Name[1]	Reported by	India	Texas
TREE-BUSH (CON'T.)				
Sissoo, sheesham[6]	*D. sissoo*	Mirza and Waiz 1973	0	
	Dichrostachys cinerea[7]	Oza 1976	0	
Madith	*Dicrostonyx cinera*[7]	Berwick 1974	0	
Timbervo	*Diospyros melanoxylon*	Berwick 1974	0	
Alma	*Emblica officinalis*	Berwick 1974	0	
	E. tseriamcottam	Schaller 1967	0	
Lodri	*Flacourtia indica*	Berwick 1974	0	
Dhraman, tadusalu, tadsal	*Grewia populifolia*	Dharmakumarsinhji 1967	0	
Dhraman, tadusalu, tadsal	*G. tiliafolia*[8]	Berwick 1974	0	
Lana	*Haloxylon recurvum*	Mirza and Waiz 1973	0	
Aterdi	*Helicteres isora*	Berwick 1974	0	
Ashe juniper, cedar	*Juniperus ashei*	Kerr Area study		X
Khip	*Leptadenia pyrotechnica*	Mirza and Waiz 1973	0	
	Leucaena glauca	Dharmakumarsinhji 1967	0	
	Mimusops hexandra	Dharmakumarsinhji 1967	0	
	Peltoforum ferrugineum	Dharmakumarsinhji 1967	0	
Honey mesquite	*Prosopis glandulosa*	Kerr Area study		X
	P. juliflora	Dharmakumarsinhji 1967	0	
Jandi	*P. spicigera*	Mirza and Waiz 1973	0	
		Oza 1976	0	
Wild plum, hog plum, chickasaw plum	*Prunus angustifolia*	Kerr Area study		X
White shin oak	*Quercus durandii* var. *breviloba*	Kerr Area study		X
Blackjack oak	*Q. marilandica*	Kerr Area study		X
Texas oak, Spanish oak	*Q. shumardi* var. *texana*	Kerr Area study		X
Post oak	*Q. stellata*	Kerr Area study		X
Live oak	*Q. virginiana* var. *virginiana*	Kerr Area study		X
Willow	*Salix* sp.	Taibel 1937		
Silk cotton, buruga	*Salmalia malabarica*[9]	Dharmakumarsinhji 1967	0	
Jal, meetijar	*Salvadora oleoides*	Mirza and Waiz 1973	0	
Pilu, piludo	*S. persica*	Dharmakumarsinhji 1967	0	
		Oza 1976	0	
Texas sophora, Eve's necklace	*Sophora affinis*	Kerr Area study		X
Ron	*Soymida febrifuga*	Berwick 1974	0	
	Tecomella undulata	Dharmakumarsinhji 1967	0	
Sajad	*Terminalia crenulata*	Berwick 1974	0	
Laurel, mathi, karimarudu	*T. tomentosa*	Berwick 1974	0	
Ziato	*Triumfetta rotundifolia*	Dharmakumarsinhji 1967	0	
Dudhalo	*Wrightia tinctoria*	Berwick 1974	0	
Mindhul	*Xeromphis spinosa*	Berwick 1974	0	
	Zizyphus jujuba	Dharmakumarsinhji 1967	0	
Bordi	*Z. mauritiana*	Berwick 1974	0	
	Z. rotundifolia	Dharmakumarsinhji 1967	0	

[8] Spillett (1968) agrees with Hooker (1872-97) in spelling the species name *Grewia tiliaefolia*.
[9] Hooker (1872-97) gives this as a synonym for *Bombax malabaricum*.Spillett (1968) gives the name as *Salmalia malabaricum*.

APPENDIX G Parasites

These parasites have been found in blackbuck. Although some were recovered in India (0) and some were recovered in Texas (X), others were recovered elsewhere in the world and no location designation is given for these captives. Many species have been recovered, but, as explained in Chapter 10, few cause significant problems.

Taxon and Site	Scientific Name[1]	Reported by	India	Texas
Phylum: Protozoa				
Subphylum: Sporozoa				
Small intestine	*Eimeria* sp. Schneider	Singh and Pande 1963	0	
		Schmied 1973		
		Robinson pers. comm.		X
Phylum: Platyhelminthes				
Class: Trematoda				
Rumen	*Carymerius gregarius* (Looss 1896)	Patnaik 1964	0	
	Gastrothylax crumenifer (Creplin 1847) Otto 1896	Singh and Pande 1963	0	
	Paramphistomum gotoi Fukui 1922	Patnaik 1964	0	
Small intestine	*Homalogaster paloniae* Poirier 1883	Patnaik 1964	0	
Liver	*Fascioloides magna* (Bassi 1875) Ward 1917	Robinson pers. comm.		X
Phylum: Platyhelminthes				
Class: Cestoda				
Small intestine	*Avitellina centripunctata* (Rivolta 1874)	Singh and Pande 1963	0	
	Moniezia expansa[2] (Rudolphi 1805)	Southwell 1930	0	
	Thysanosoma actinioides Diesing 1835	Galvin pers. comm.		X
Peritoneal cavity	*Taenia hydatigena* (larva) Pallas 1766	Thornton *et al.* 1973a		X
Brain	*Multiceps* sp. (larva) Goeze 1782	Rewell 1948		
Phylum: Nematoda				
Abomasum	*Camelostrongylus mentulatus* (Railliet and Henry 1909)	Jansen 1959.		
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	Haemonchus contortus (Rudolphi 1803)	Travassos 1937		
		Sloan 1951		
		Singh and Pande 1963	0	
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	Ostertagia circumcincta (Stadelmann 1894)	Sloan 1951.		
		?Thornton *et al.* 1973b		?
	O. skrjabini? Singh and Pande 1963	Singh and Pande 1963	0	

[1] Nomenclature for the internal parasites of blackbuck follows Yamaguti's series, Systema Helminthum, for the trematodes (Yamaguti 1958), the cestodes (Yamaguti 1959) and the nematodes (Yamaguti 1961), with the exception that the spelling of the name for the nematode parasite *Bunostomum bhavanagarensis* follows the original authors. Kudo (1966) supplied the authority for the protozoan parasite genus *Eimeria*. Similarly, James and Harwood (1969) supplied the authorities for the external parasites. See note 1, Appendix A, for use of authorities in parentheses.

[2] Yamaguti (1959) lists *Moniezia trigonophora* as recorded in *Antilope cervicapra*, but Southwell (1930) lists only *Moniezia expansa* for blackbuck, giving *M. trigonophora* as a synonym of *M. expansa*.

Taxon and Site	Scientific Name[1]	Reported by	India	Texas
	O. trifurcata Ransom 1907	Sloan 1951		
	Ostertagia sp. Ransom 1907	Schmied 1973		
	Trichostrongylus axei[3] (Cobbold 1879)	Sloan 1951		
		Jansen 1959		
		Singh and Pande 1963	0[4]	
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	T. colubriformis[3] (Giles 1892)	Singh and Pande 1963	0	
	T. vitrinus[3] (Looss 1905)	Sloan 1951		
		Jansen 1959		
	Trichostrongylus sp.[3] Looss 1905	Schmied 1973		
Small intestine	*Bunostomum bhavanagarensis*[5] Ramanujachari and Alwar 1951	Ramanujachari and Alwar 1951	0	
	B. trigonocephalum (Rudolphi 1808)	Singh and Pande 1963	0	
		Wetzel and Fortmeyer 1965		
	Cooperia laterouniformis Chen 1937	Singh and Pande 1963	0	
	Gaigeria pachyscelis Railliet and Henry 1910	Singh and Pande 1963	0	
	Nematodirus spathiger (Railliet 1896) Railliet and Henry 1909	Jansen 1959.		
		Thornton *et al.* 1973a		X
	Trichostrongylus axei[3] (Cobbold 1879)	Sloan 1951.		
		Singh and Pande 1963	0[4]	
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	T. colubriformis[3] (Giles 1892)	Sloan 1951		
		Jansen 1959		
		Singh and Pande 1963	0	
		Wetzel and Fortmeyer 1965		
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	T. probolurus (Railliet 1896)	Jansen 1959		
		Thornton *et al.* 1973a		X
		Thornton *et al.* 1973b		X
	T. retortaeformis (Zeder 1800)	Sloan 1951		
	T. vitrinus[3] Looss 1905	Sloan 1951		
		Jansen 1959		
	Trichostrongylus sp.[3]	Schmied 1973		
Phylum: Nematoda				
Large intestine	*Oesophagostomum* sp. Molin 1861	Singh and Pande 1963	0	
		Thornton *et al.* 1973a		X
	Skrjabinema ovis (Skrjabin 1915) Wereschtchagin 1926	Singh and Pande 1963	0	
	Skrjabinema sp.[6] Wereschtchagin 1926	Galvin pers. comm.		X

[3] Same species found in abomasum and in small intestine.

[4] It is unclear whether Singh and Pande (1963) found *Trichostrongylus axei* in duodenum or abomasum or both. Only three specimens (males) were recovered. Only Singh and Pande (1963) report this species from India.

[5] Although listed by Ramanujachari and Alwar (1951) as a "cross-bred deer" resulting from an *Antilope cervicapra X Cervus dama* mating, the host was almost certainly an albino blackbuck. (For albinism see Chapter 1, and for more on hybrids see Chapter 3.)

[6] A broken specimen of *Skrjabinema* sp. was found in one Texas blackbuck. *Skrjabinema* sp. recovered by Thornton *et al.* (1973b) in Texas from one sheep and two goats inoculated with infective larvae from Texas blackbuck were not considered to have been transmitted by the inoculation because of the life cycle of the parasite.

(Continued on next page)

Taxon and Site	Scientific Name[1]	Reported by	India	Texas
	Trichuris cervicaprae Kreis 1935	Kreis 1935 ?Patnaik 1964	?	
	T. globulosa (Linst 1901)	Thornton 1972		X
	T. ovis (Abildgard 1795)	Singh and Pande 1963[7]	0	
Peritoneal cavity	*Artionema hartwichi* Yeh 1959[8]	Singh and Pande 1963	0	
	?Papillosetaria veversi Maplestone 1931	Singh and Pande 1963	0	
Phylum: Arthropoda Class: Arachnida External body surface	*Amblyomma americanum* Linnaeus	Thornton *et al.* 1973a		X
Phylum: Arthorpoda Class: Insecta External body Surface	*Tricholipeurus parallelus* Osborn	Thornton *et al.* 1973a		X

[7] Singh and Pande (1963) indicate that *Trichuris ovis* had previously been recorded outside India in blackbuck, but the source of the report is unclear (perhaps Smith 1903 *in* Singh and Pande 1963).

[8] Singh and Pande (1963) use the date of Yeh's 1959 publication which describes *Artionema hartwichi* as a new species. Yamaguti's (1961) reference to 1953 is probably a misprint.

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LITERATURE CITED

ABLES, E. D., Z. L. CARPENTER, L. QUARRIER and W. J. SHEFFIELD. 1973. Carcass and meat characteristics of nilgai antelope. Texas Agric. Exp. Stn., Texas A&M University, College Station, Tex. 8 pp.

_____ and C. W. RAMSEY. 1974. Indian mammals on Texas rangelands. J. Bombay Nat. Hist. Soc. 71(1):18-25.

ABROMAVICH, C. E., JR. 1930. Uterus and fetal membranes of the Indian antelope (Antilope cervicapra). Anat. Rec. 46(2):105-124.

ABUL FAZI 'ALLAMI. 1873. The Ain i Akbari, I, trans. H. Blockmann. Asiatic Society of Bengal, Calcutta. 678 pp.

_____. 1972. The Akbarnāma of Abu-l-Faẓl, II, trans. H. Beveridge. Asiatic Society of Bengal, Delhi, India. 600 pp.

ACHARJYO, L. N., and R. MISRA. 1973. A note on age of sexual maturity of two species of antelopes in captivity. J. Bombay Nat. Hist. Soc. 70(2):378.

AFIAIO, F. G., ed. 1904. The sportsman's book for India. Horace Marshall & Son, London. 567 pp.

AHMAD, K. S. 1958. Punjab. Encyclo. Britannica. 18:772-773.

ALI, S. A. 1927. The Moghul emperors of India as naturalists and sportsmen, part II. J. Bombay Nat. Hist. Soc. 32(1):34-63.

ALLISON, J. E., G. W. DITTMAR & J. L. HENSELL. 1975. Soil survey of Gillespie County, Texas. USDA, SCS in cooperation with Texas Agric. Exp. Stn. 80 pp.

ANONYMOUS. 1970a. Blackbuck for Pakistan. 1970. Oryx. 10(5):286-287.

ANONYMOUS. 1970b. Texas to Pakistan: antelope herd going 'home.' San Antonio Light, Wed., Apr. 15, cols. 1-5.

ANONYMOUS. 1971. The compact edition of the Oxford English dictionary, I, A-O. Oxford University Press, New York. 2,048 pp.

ANONYMOUS. 1974. Penal Auxiliary Laws, Art. 892. West's Texas statutes and codes, compact ed., I. West Publishing Co., St. Paul, Minn. P. 975.

ANONYMOUS. 1975a. Endangered and threatened wildlife and plants. Federal Reg. 40(131):28,714-28,720.

ANONYMOUS. 1975b. Legget gains delay in injurious wildlife regs. ZooAction, July. P. 3.

ANONYMOUS. 1976. Activity report. Exotic Wildl. Assoc. Sept. 1. 3 pp.

ARMAN, P., R. N. B. KAY, E. D. GOODALL AND G. A. M. SHARMAN. 1974. The composition and yield of milk from captive red deer (*Cervus elaphus* L.). J. Reprod. Fert. 37(1):67-84.

ASCHAFFENBURG, R., M. E. GREGORY, S. K. KON, S. J. ROWLAND and S. Y. THOMPSON. 1962. The composition of the milk of the reindeer. J. Dairy Res. 29(3):325-328.

ASDELL, S. A. 1964. Patterns of mammalian reproduction, 2nd ed. Comstock Publishing Associates, Ithaca, N. Y. 670 pp.

BĀBUR. 1922. The Bābur-nāma in English (memoirs of Bābur), II, trans. A. S. Beveridge. AMS Press, New York. 436 pp.

BACKHAUS, D. 1958. Beitrag zur Ethologie der Paarung einer Antilopen. Zuchthygiene. 2:281-293.

BADĀONI. 1973. Muntakhabu't-Tawārīkh, II, trans. W. H. Lowe, 2nd ed., IAD Oriental Series No. 20, Bibliotheca Indica, work no. 97. Idarah-i-Adabiyat-i-Delli, Delhi, India. 506 pp.

BAKER, S. W. 1890. Wild beasts and their ways. Macmillan and Co., New York. 455 pp.

BALDWIN, J. H. 1876. Large and small game of Bengal and the north-western provinces of India. Henry S. King & Co., London. 380 pp.

BANKS, R. C. 1976. Wildlife importation into the United States, 1900-1972. U.S. Dept. Interior, Fish and Wildlife Service, Special Sci. Rep. — Wildl. No. 200. 18 pp.

BANNIKOV, A. G., L. V. ZHIRNOV, L. S. LEBEDEVA and A. A. FANDEEV. 1967. Biology of the saiga, ed. A. G. Bannikov, [trans. M. Fleischmann]. U.S. Dept. Interior and Nat. Sci. Foundation, Washington, D.C. 252 pp.

BARRETT, P. 1968. Great hunting in the land of the gauchos. True, March. Pp. 52-53, 88-89, 92-95.

BASHAM, A. L. 1959. The wonder that was India. Grove Press, Inc., New York. 568 pp.

BASU, S. 1973. Weather and climate. *In*: The gazetteer of India, I, The Gazetteers Unit. Publications Division, Ministry of Information and Broadcasting, Government of India, Faridabad, India. Pp. 67-116.

BEDFORD, HIS GRACE THE DUKE OF, and F. H. A. MARSHALL. 1942. On the incidence of the breeding season in mammals after transference to a new latitude. Proc. Roy. Soc. London, series B. 130(B861):396-399.

BENNETT, E. T. 1836. Remarks upon a series of the *Indian antelope* (*Antilope cervicapra*, Pall.). Proc. Zool. Soc. London, pt. IV. Pp. 34-36.

BEN SHAUL, D. M. 1962. The composition of the milk of wild animals. Int. Zoo Yrbk. 4:333-342.

BENZ, M. 1973. Zum Sozialverhalten der Sasin (Hirschziegenantilope, *Antilope cervicapra* L. 1758). Zoologische Beitrage, n.F. 19(3):403-466.

BERWICK, S. H. 1974. The community of wild ruminants in the Gir Forest ecosystem, India. Ph.D. dissertation, Yale University, New Haven, Conn. (Unpub.). 226 pp.

BLANFORD, W. T. 1873. Note on the gazelles of India and Persia, with description of a new species. Proc. Zool. Soc. London. Pp. 313-319.

_____. 1888-91. The fauna of British India, including Ceylon and Burma, Mammalia, series ed. W. T. Blanford. Taylor and Francis, London. 617 pp.

BLOM, E. 1968. Male reproductive organs. *In*: E. S. E. Hafez, ed. Reproduction in farm animals, 2nd ed. Lea & Febiger, Philadelphia. Pp. 27-37.

BOKHARI, A. S. 1970. Re-introduction of blackbucks (*Antelope* [*sic*] *cervicapra* [spelling corrected]) in Lal Sohanra [*sic*] Game Sanctuary of Bahawalpur District. Pakistan J. Forest. 20(4):393-395.

BOURLIERE, F. 1967. The natural history of mammals, trans. H. M. Parshley, 3rd (rev.) ed., Borzoi Books, Alfred A. Knopf, New York. 399 pp.

BRADLEY, R. M. 1977. Aspects of the ecology of the Thomson's gazelle in the Serengeti National Park, Tanzania. Ph.D. dissertation, Texas A&M University, College Station, Tex. (Unpub.). 263 pp.

BRANDER, A. A. D. 1923. Wild animals in central India. Edward Arnold & Co., London. 296 pp.

BRAIZLER, L. J. 1971. Palatability factors and evaluation. *In*: J. F. Price and B. S. Schweigert, eds. The science of meat and meat products, 2nd ed. W. H. Freeman and Company, San Francisco. Pp. 328-348.

BRISTOW, C. H. 1925. Determination of the age in blackbuck. J. Bombay Nat. Hist. Soc. 30(2):469-470.

BROWN, C. E. 1936. Rearing wild animals in captivity, and gestation periods. J. Mammal. 17(1):10-13.

BROTHERS, A., and M. E. RAY, JR. 1975. Producing quality whitetails. Wildlife Services, Laredo, Tex. 246 pp.

BUDDEN, J. 1921. Black buck *v.* motor. J. Bombay Nat. Hist. Soc. 27(4):939.

BUFFON, G. L. L. 1764. Histoire naturelle, générale et particuliére [*sic*], avec la description du cabinét du roi, XII. De L'Imprimerie Royale, Paris. 452 pp.

BUSSABARGER, R. F., and B. D. ROBINS. 1968. The everyday art of India. Dover Publications, Inc., New York. 205 pp.

C. 1902. Hints on blackbuck shooting. The Asian, cols. 1-3 & 1-2. 48:702-703.

CARR, J. T., JR. 1969. The climate and physiography of Texas, rep. 53. Texas Water Dev. Board. 27 pp.

CARY, E. R. 1976a. Blackbuck menu. Texas Pk. Wildl. 34(4):16-18.

_____. 1976b. Territorial and reproductive behavior of the blackbuck antelope (*Antilope cervicapra*). Ph.D. dissertation, Texas A&M University, College Station, Tex. (Unpub.). 220 pp.

_____, M. J. ANDEREGG, B. ARMSTRONG and staff of the Kerr Wildlife Management Area. 1975. Plants of the Antelope Rangeland, South Fork Ranch. Blackbuck Behavior Proj., Dept. Wildl. Fish Sci., Texas A&M Univ., in cooperation with Kerr Wildl. Manage. Area, Texas Pk. Wildl. Dept. (Unpub.). 32 pp.

CASADY, R. B., R. M. MEYERS and J. E. LEGATES. 1953. The effect of exposure to high ambient temperature on spermatogenesis in the dairy bull. J. Dairy Sci. 36(1):14-23.

CHATTERJEE, S. P. 1973. Physiography. *In*: The gazetteer of India, I, The Gazetteers Unit. Publications Division, Ministry of Information and Broadcasting, Government of India, Faridabad, India. Pp. 1-65.

CHEN, E. C. H., D. A. BLOOD and B. E. BAKER. 1965. Rocky Mountain bighorn sheep (Ovis canadensis canadensis) milk I. gross composition and fat constitution. Canadian J. Zool. 43(5):885-888.

COLLINS, W. 1946. The moonstone. Doubleday & Company, Inc., Garden City, N. Y. 444 pp.

COOK, H. W., A. M. PEARSON, N. M. SIMMONS and B. E. BAKER. 1970. Dall sheep (*Ovis dalli dalli*) milk. I. Effects of stage of lactation on the composition of the milk. Canadian J. Zool. 48(4):629-633.

COOK, R. L. 1972. Habitat preference of exotics, job no. 18, Kerr Wildl. Manage. Area Res., Federal Aid Proj. No. W-76-R-15, job progress rep., Tex. Pk. Wildl. Dept. 20 pp.

COOKE, H. B. S. 1972. The fossil mammal fauna of Africa. *In*: A. Keast, F. C. Erk and B. Glass. Evolution, mammals and southern continents. State University of New York Press, Albany, N. Y. Pp. 89-139.

CRANDALL, L. S. 1964. The management of wild mammals in captivity. University of Chicago Press, Chicago. 769 pp.

DANIEL, J. C. 1967. The Point Calimere Sanctuary, Madras State-May 1967. J. Bombay Nat. Hist. Soc. 64(3):512-523.

DAVIS, W. B. 1974. The mammals of Texas, bull. no. 41, rev. ed. Texas Pk. Wildl. Dept., Austin, Tex. 294 pp.

DEEVEY, E. S., JR. 1947. Life tables for natural populations of animals. Quart. Rev. Biol. 22(4):283-314.

DHARMAKUMARSINHJI, K. S. 1959. A field guide to big game census in India, Leaflet No. 2. Indian Board for Wild Life, New Delhi. 94 pp.

_____. 1967. Browsing behaviour of (*Gazella g. bennetti*) and (*Antilope cervicapra*) in captivity and natural habitat. Int. U. Forest. Res. Organ., XIV Congr., sect. 26, Munich. Pp. 424-465.

DHARMAKUMARSINHJI, R. S., and S. F. GAIKWAD. 1958. The blackbuck. Indian Board for Wild Life. 4 pp.

DILL, C. W., P. T. TYBOR, T. MCGILL and C. W. RAMSEY. 1972. Gross composition and fatty acid constitution of blackbuck antelope (*Antilope cervicapra*) milk. Canadian J. Zool. 50(8):1127-1129.

DOLLMAN, G., and J. B. BURLACE, eds. 1935. Rowland Ward's rec-

Fund, n.s., XXII. Royal Asiatic Society, London.

JAMES, M. T., and R. F. HARWOOD, 1969. Herm's Medical Entomology, 6th ed. Collier-Macmillan Limited, London. 484 pp.

JANSEN, J., JR. 1959. *Auchenia glama* and *Antilope cervicapra*, new hosts for some Trichostrongylidae. J. Parasitol. 45(5):509.

JARVIS, C., and D. MORRIS, eds. 1961. The breeding seasons of mammals in captivity. Int. Zoo Yrbk. 3:292-301.

JENNESS, R., and R. E. SLOAN. 1970. The composition of milks of various species: a review. Dairy Sci. Abstr. 32(10):599-612.

JERDON, T. C. 1874. The mammals of India. John Wheldon, London. 335 pp.

KATONGOLE, C. B., F. NAFTOLIN and R. V. SHORT. 1971. Relationship between blood levels of luteinizing hormone and testosterone in bulls, and the effects of sexual stimulation. J. Endocr. 50(3):457-466.

KEISS, R. E. 1969. Comparison of eruption-wear patterns and cementum annuli as age criteria in elk. J. Wildl. Manage. 33(1):175-180.

KELLY, J. A. 1970. Food habits of four exotic big-game animals on a Texas "Hill Country" ranch. M.S. thesis, Texas A&I University, Kingsville, Tex. (Unpub.). 100 pp.

KIPLING, R. 1912. Kim. Doubleday Page & Company, Garden City, N. Y. 355 pp.

KITTS, W. D., I. M. COWAN, J. BANDY and A. J. WOOD. 1956. The immediate post-natal growth in the Columbian black-tailed deer in relation to the composition of the milk of the doe. J. Wildl. Manage. 20(2):212-214.

KREIS, H. A. 1935. Beiträge zur Kenntnis parasitischer Nematoden. 1. Ein neuer parasitischer Nematode aus der Hirschziegenantilope, *Antilope cervicapra* L.: *Trichuris cervicaprae*, n. sp. (*Trichurinae* Ransom, 1911; *Trichuridae* Ransom, 1911; *Trichuridae* Railliet, 1915; *Trichuroidea* Railliet, 1916). Verhandl. Naturf. Gesell. Basel. 46:59-65.

KRISHNAN, M. 1971. An ecological survey of the larger mammals of peninsular India, 1st pt. J. Bombay Nat. Hist. Soc. 68(3):503-536.

_____. 1972. An ecological survey of the larger mammals of peninsular India (cont.). J. Bombay Nat. Hist. Soc. 69(3):469-501.

KRUMBIEGEL, I. 1954. Biologie der Säugetier, I. Agis-Verlag, Krefeld, Germany. 355 pp.

_____. 1955. Biologie der Säugetier, II. Agis-Verlag, Krefeld, Germany. 844 pp.

KUDO, R. R. 1966. Protozoology, 5th ed. Charles C. Thomas, Springfield, Ill. 1174 pp.

LASLEY, J. F. 1968. Estrous cycles. *In*: E. S. E. Hafez, ed. Reproduction in farm animals, 2nd ed. Lea & Febiger, Philadelphia. Pp. 81-97.

LEE, J., and F. G. W. KNOWLES. 1965. Animal hormones. Hutchinson University Library, London. 192 pp.

LINCOLN, G. A., and F. E. GUINNESS. 1972. Effect of altered photoperiod on delayed implantation and moulting in roe deer. J. Reprod. Fert. 31(3):455-457.

LINNAEUS, C. 1956. Caroli Linnaei systema naturae: a photographic facsimile of the first volume of the tenth edition (1758), Regnum animale. British Museum (Natural History), London. 824 pp.

LITTON, G. 1975. Pronghorn progress. Texas Pk. & Wildl. 33(3):16-19.

LODER, E. G. 1894. Note on the period of gestation of the Indian antelope, *Antilope cervicapra* (Linn.). Proc. Zool. Soc. London. P. 476.

LORENZ, K. 1966. On aggression, trans. M. K. Wilson, A. Helen and Kurt Wolff Book. Harcourt, Brace & World, Inc., New York. 306 pp.

LOWE, V. P. W. 1967. Teeth as indicators of age with special reference to red deer (*Cervus elaphus*) of known age from Rhum. J. Zool. (London). 152:137-153.

LYDEKKER, R. 1893. Horns and hoofs. Horace Cox, London. 411 pp.

_____. 1907. The game animals of India, Burma, Malaya, and Tibet. Rowland Ward, Limited, London. 409 pp.

_____. 1913. Catalogue of the heads and horns of Indian big game bequeathed by A. O. Hume, C. B., to the British Museum (Natural History). British Museum (Natural History), London. 45 pp.

MACFARLANE, W. V. 1964. Terrestrial animals in dry heat: ungulates. *In*: Adaptation to the environment, sect. 4, Handbook of physiology. American Physiological Society, Washington, D. C. Pp. 509-537.

MACLAREN, A. 1968. Fertilization, cleavage and implantation. *In*: E. S. E. Hafez, ed. Reproduction in farm animals, 2nd ed. Lea & Febiger, Philadelphia. Pp. 115-133.

MANN, W. M. 1934. Wild animals in and out of the zoo, VI, Smithsonian Scientific Series. Smithsonian Institution Series, Inc., New York. 362 pp.

MARBURGER, R. G., R. M. ROBINSON, J. W. THOMAS, M. J. AND[E]REGG and K. A. CLARK. 1972. Antler malformation produced by leg injury in white-tailed deer. J. Wildl. Dis. 8:311-314.

MEINERTZHAGEN, R. 1938. Some weights and measurements of large mammals. Proc. Zool. Soc. London, series A. 108(3):433-439.

MIRARCHI, R. E., P. F. SCANLON, R. L. KIRKPATRICK and C. B. SCHRECK. 1977. Androgen levels and antler development in captive and wild white-tailed deer. J. Wildl. Manage. 41(2):178-183.

MIRZA, Z. B., and A. WAIZ. 1973. Food availability for blackbuck (*Antilope cervicapra*) at Lal Suhanra Sanctuary, Pakistan. Biol. Conserv. 5(2):119-122.

MOUNTFORT, G. 1970-71. Project 474 Lal Suhanra Reserve, Pakistan. World Wildlife Yearbook 1970-71. Pp. 109-110.

MUNGALL, E. C. 1977. Social development of the young blackbuck antelope (*Antilope cervicapra*). AAZPA Regional Conf. Proc. 1977. (In press).

_____, R. W. SPAIN, R. J. WHITE and R. M. ROBINSON. Horned blackbuck female. (In press).

MURPHY, D. A. 1960. Rearing and breeding white-tailed fawns in captivity. J. Wildl. Manage. 24(4):439-441.

ORTON, R. 1971. Kerrville, surroundings famous for pleasant, healthful clime (part authorship, remainder anonymous), sect. D, Kerr County Progress 1971. Kerrville (Texas) Daily Times, cols. 6-8. P. 6D.

OZA, G. M. 1976. The blackbuck of Baroda. Sci. Today. 10(11):49.

_____. 1977. Should the blackbuck survive? 3rd Ann. Conf. Assoc. Clinical Biochemists of India, Baroda. 4 pp.

_____ and A. C. GAEKWAD. 1973. Blackbuck faces extinction in India. Biol. Conserv. 5(3):234-235.

_____ and _____. 1974. Blackbuck and *Desmostachya bipinnata* (L.) Stapf. Cheetal. 16(1):31-32.

PALLAS, P. S. 1767. Specilegia zoologica quibus novae imprimis et obscurae animalium species iconibus, descriptionibus atque commentarus illustratur, I. Gottl. August. Lange, Berolini. 44 pp.

PALMER, H. C. 1973. Catalog of and instructions for use of Cap-Chur equipment. Palmer Chemical & Equipment Co., Inc., Palmer Village, Ga. 36 pp.

PALMER, T. S. 1904. Index generum mammalium: a list of the genera and families of mammals, North American Fauna, No. 23, USDA, Division of Biological Survey. Government Printing Office, Washington, D.C. 984 pp.

PAINAIK, M. M. 1964. A note on the helminth parasites of the blackbuck (*Antilope cervicapra*). Current Sci. 33(6):180.

PEARSON, A. M. 1971. Muscle function and post-mortem changes. *In:* J. F. Price and B. S. Schweigert, eds. The science of meat and meat products, 2nd ed. W. H. Freeman and Company, San Francisco. Pp. 208-229.

PENROSE, C. B. 1924. Removal of the testicle in a sika deer followed by deformity of the antler on the opposite side. J. Mammal. 5(2):116-118.

PERCY, R. H. 1894. Indian shooting. *In:* C. Phillips-Wolley. Big game shooting, II, The Badminton Library. Longmans, Green, and Co., London. Pp. 182-362.

PILGRIM, G. E. 1939. The fossil bovidae of India. Mem. Geol. Surv. India, Palaeontologia India, n.s. 26(1):1-356.

POCOCK, R. I. 1910. On the specialized cutaneous glands of ruminants. Proc. Zool. Soc. London. Pp. 840-986.

POLO, MARCO. 1953. The travels of Marco Polo, the Venetian, rev. ed., trans. Marsden, ed. Manuel Kamroff. Liveright, New York. 370 pp.

PRAKASH, I. 1975. The amazing life in the Indian desert, our birds, animals, trees, Annual '75. The Illustrated Weekly of India. Pp. 96-121.

PRATER, S. H. c 1948. The book of Indian animals. Bombay Natural History Society, Bombay. 262 pp.

_____. 1971. The book of Indian animals, 3rd (rev.) ed. Bombay Natural History Society, Bombay. 324 pp.

PUTMAN, J. J. 1976. India struggles to save her wildlife. Nat. Geogr. 150(3):298-343.

QUIMBY, D. C., and J. E. GAAB. 1957. Mandibular dentition as an age indicator in Rocky Mountain elk. J. Wildl. Manage. 21(4):435-451.

RAMANUJACHARI, G., and V. S. ALWAR. 1951. Bunostomum bhavanagarensis n. sp. Indian Vet. J. 27(4):239-243.

RAMSEY, C. W. 1968. A drop-net deer trap. J. Wildl. Manage. 32(1):187-190.

_____. 1969. Texotics, Bull. No. 49. Texas Pk. Wildl. Dept. 46 pp.

_____. 1972. Exotic game ranching expensive, experimental. Texas Agric. Progr. 18(3):9-12.

RAO, H. S. 1957. History of our knowledge of the Indian fauna through the ages. J. Bombay Nat. Hist. Soc. 54(2):251-280.

REWELL, R. E. 1948. Diseases of tropical origin in captive wild animals. Trans. Roy. Soc. Trop. Med. Hyg. 42(1):17-25.

RITCHIE, J. 1940. Upper canine teeth in the Indian antelope (*Antilope cervicapra*). Nat. (London). 145(3683):859.

SARKAR, S., ed. 1975. Hindustan year-book and who's who 1975, pt. I. M. C. Sarkar & Sons Private Ltd., Calcutta. 784 pp.

SCHALLER, G. B. 1967. The deer and the tiger. The University of Chicago Press, Chicago. 370 pp.

SCHMIED, A. 1973. Beiträge zu einem Aktionssystem der Hirschziegenantilope (*Antilope cervicapra* Linné 1758). Z. Tierpsychol. 32:153-198.

SCHREINER, C., III. 1968. Uses of exotic animals in a commercial hunting program. *In:* Sym.: Introduction of Exotic Animals: Ecologic and socioeconomic considerations. Caesar Kleberg Research Program in Wildlife Ecology, College of Agriculture, Texas A&M University, College Station, Tex. Pp. 13-16.

SCLATER, P. L., and O. THOMAS. 1897-98. The book of antelopes, III. R. H. Porter, London. 245 pp.

SELLARDS, E. H., W. S. ADKINS and F. B. PLUMMER. 1932. The geology of Texas, I, Stratigraphy. Univ. Texas Bull. No. 3232. 1007 pp.

SESHADRI, B. 1969. The twilight of India's wild life. John Baker Publishers, London. 212 pp.

SEVERINGHAUS, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. J. Wildl. Manage. 13(2):195-216.

_____ and E. L. CHEATUM. 1969. Life and times of the white-tailed deer. *In:* W. P. Taylor, ed. The deer of North America. The Stackpole Company, Harrisburg, Pa., and The Wildlife Management Institute, Washington, D.C. Pp. 57-186.

SILVER, H. 1961. Deer milk compared with substitute milk for fawns. J. Wildl. Manage. 25(1):66-70.

SIMMONDS, M. H., H. H. THE MAHARAJA OF DHAR, C. H. STOCKLEY, F. L. ANDREWS, B. A. ROKEBY and M. WYLIE. 1923. Change of colour in the blackbuck (*Antilope cervicapra*). J. Bombay Nat. Hist. Soc. 29:834-837.

SIMMONS, L. G. 1974. Frostbite in antelope horns. AAZPA Regional Conf. Proc. 1974. Pp. 57-58.

SIMPSON, C. D. 1971. Horn growth as a potential age criterion in some southern African antelopes. J. South. Afr. Wildl. Manage. Assoc. 1(1):20-25.

SINGH, P. P., and B. P. PANDE. 1963. Helminths collected from the Indian antelope, *Antilope cervicapra*. Ann. Parasitol.: Humaine et Comparee. 38(3):439-457.

SINGH, S. 1928. Abnormal blackbuck and a good chinkara head from Bikanir. J. Bombay Nat. Hist. Soc. 32(3):593.

SLOAN, J. E. N. 1951. A note on the occurrence of *Trichstrongylus retortaeformis* in the blackbuck (*Antilope cervicapra*). Proc. Zool. Soc. London. 121(3):723-725.

SMITH, C. A. 1968. Protecting the United States against diseases of foreign origin. *In:* Sym.: Introduction of Exotic Animals: Ecologic and socio-economic considerations. Caesar Kleberg Research Program in Wildlife Ecology, College of Agriculture, Texas A&M University, College Station, Tex. Pp. 23-25.

SMITH, F. C., R. A. FIELD and J. C. ADAMS. 1974. Microbiology of Wyoming big game meat. J. Milk Food Technol. 37(3):129-131.

SOUTHWELL, T. 1930. The fauna of British India, including Ceylon and Burma, Cestoda, II, ed. J. Stephenson. Taylor and Francis, London. 262 pp.

SPINAGE, C. A. 1967. Aging the Uganda defassa waterbuck *Kobus defassa ugandae* Neumann. E. Afr. Wildl. J. 5:1-17.

_____. 1971. Geratodontology and horn growth of the impala (*Aepyceros melampus*). J. Zool. (London). 164:209-225.

_____. 1973. A review of the age determination of mammals by means of teeth, with especial reference to Africa. E. Afr. Wildl. J. 11(2):165-187.

_____. 1976. Age determination of the female Grant's gazelle. E. Afr. Wildl. J. 14(2):121-134.

SPILLETT, J. J. 1966. The blackbuck of Sikandra Uttar Pradesh. J. Bombay Nat. Hist. Soc. 63(3):599-601.

_____. 1968. A report on wild life surveys in south and west India November-December 1966. J. Bombay Nat. Hist. Soc. 65(1):1-46, (2):296-325, (3):633-663.

_____ and K. M. TAMANG. 1966. Wild life conservation in Nepal. 63(3):557-572.

STEBBING, E. P. 1911. Jungle by-ways in India. John Lane Company, New York. 307 pp.

STERNDALE, R. A. 1884. Natural history of the Mammalia of India and Ceylon. Thacker and Co., London. 540 pp.

STILWELL, H. 1955. Old-World hunt in Texas. Field & Stream. 60(1):68-69, 143-146.

STOCKLEY, C. H. 1928. Big game shooting in the Indian Empire. Constable and Company Ltd., London. 200 pp.

STRONG, H. F. 1907. Black buck horns. The Asian, March 30, col. 2. 57:667.

TAIBEL, A. M. 1937. L'Antilope cervicapra: osservazioni sul gruppo in allevamento presso la Stazione sperimentale di Avicultura di Rovigo. Rassegna Faunistica (Roma). 4(2):3-19.

TAYLOR, C. R. 1972. The desert gazelle: a paradox resolved. Sym. Zool. Soc. London. No. 31:215-227.

TAYLOR, F. B., R. B. HAILEY and D. L. RICHMOND. 1966. Soil survey of Bexar County, Texas. USDA, SCS in cooperation with Texas Agric. Exp. Stn. 126 pp.

TEER, J. G. 1974. Game ranching in Texas. *In*: V. Geist and F. Walther. The behaviour of ungulates and its relation to management, II. IUCN, n.s., no. 24. Pp. 893-899.

TEMPLE, T. B. 1976. Records of exotics, I. Thompson B. Temple, Kerrville, Texas. 146 pp.

THORNTON, J. E. 1972. Parasites of blackbuck antelope (*Antilope cervicapra*) in Texas and experimental transmission of gastrointestinal helminths from blackbuck to domestic ruminants. M. S. thesis, Texas A&M University, College Station, Tex. (Unpub.). 42 pp.

_____, T. J. GALVIN, R. R. BELL and C. W. RAMSEY. 1973a. Parasites of the blackbuck antelope (*Antilope cervicapra*) in Texas. J. Wildl. Dis. 9:160-162.

_____, _____, _____ and _____. 1973b. Transmissibility of gastrointestinal nematodes from blackbuck antelope to cattle, sheep, and goats. J. American Vet. Med. Assoc. 163(6):554-555.

TRAVASSOS, L. 1937. Revisao da familia Trichostrongylidae Leiper, 1912. Monograph, Inst. Oswaldo Cruz (Rio de Janeiro). Pp. 512.

TREUS, V., AND D. KRAVCHENKO. 1968. Methods of rearing and economic utilization of eland in the Askaniya-Nova Zoological Park. *In*: M. A. Crawford, ed. Comparative nutrition of wild animals. Sym. Zool. Soc. London, no. 21. Pp. 395-411.

TURNER, C. D. 1955. General endocrinology, 2nd ed. W. B. Saunders Company, Philadelphia.

UDDEN, J. A., C. L. BAKER and E. BOSE. 1916. Review of the geology of Texas. Univ. Texas Bull. No. 44. 178 pp.

VAN COUVERING, J. A., and J. A. MILLER. 1971. Late Miocene marine and non-marine time scale in Europe. Nat. (London). 230(5296):559-563.

VON LA CHEVALLERIE, M., and J. H. M. VAN ZYL. 1971. Some effects of shooting on losses of meat and meat quality in springbok and impala. Afr. J. Animal Sci. 1:113-116.

VAN ZYL, J. H. M., and A. S. WEHMEYER. 1970. The composition of the milk of springbok *(Antidorcas marsupialis)*, eland *(Taurotragus oryx)* and black wildebeest *(Connochaetus [sic] gnou)*. Zool. Afr. 5(1):131-133.

WADIA, D. N. 1973. Geology. *In*: The Gazetteer of India, I, The Gazetteers Unit. Publications Division, Ministry of Information and Broadcasting, Government of India, Faridabad, India. Pp. 117-162.

WALLACE, C., and N. FAIRALL. 1967. Chromosome polymorphism in the impala *(Aepyceros melampus melampus)*. S. Afr. J. Sci. 63(11):482-486.

WALTHER, F. [R.] 1958. Zum Kampf- and Paarungsverhalten einiger Antilopen. Z. Tierpsychol. 15:340-380.

_____. 1959-60. Beobachtungen zum Sozialverhalten der Sasin (Hirschziegenantilope, *Antilope cervicapra* L.). Jahrb. 1959/60 George von Opel-Freigehege fur Tierforschung. 2:64-78.

_____. 1964a. Verhaltensstudien an der Gattung *Tragelaphus* de Blainville (1816) in Gefangenschaft, unter besonderer Beruchsichtigung des Sozialverhaltens. Z. Tierpsychol. 21(4):393-467.

_____. 1964b. Zum Paarungsverhalten der Sömmeringgazelle *(Gazella soemmeringi* Cretzschmar 1826). Zool. Garten, n.F. 29:145-160.

_____. 1968. Verhalten der Gazellen. A. Ziemsen Verlag, Wittenberg, Germany. 144 pp.

_____. 1969. Flight behaviour and avoidance of predators in Thomson's gazelle *(Gazella thomsoni* Guenther 1884). Behaviour. 33(3):184-221.

_____. 1972a. The gazelles and their relatives; Subfamily: Antilopinae. *In*: B. Grzimek, ed.-in-chief. Grzimek's animal life encyclopedia, trans. L. Walther and E. Klinghammer. Van Nostrand Reinhold Company, New York. Pp. 431-448.

_____. 1972b. On age class recognition and individual identification of Thomson's gazelle in the field. J. South. Afr. Wildl. Manage. Assoc. 2(2): 9-15.

_____. 1972c. Social grouping in Grant's gazelle *(Gazella granti* Brooke 1872 [date corrected]) in the Serengeti National Park. Z. Tierpsychol. 31(4):348-403.

_____. 1972d. Territorial behavior in certain horned ungulates, with special reference to the examples of Thomson's and Grant's gazelles. Zool. Afr. 7(1):303-307.

_____. 1973. Round-the-clock activity of Thomson's gazelle *(Gazella thomsoni* Gunther 1884) in the Serengeti National Park. Z. Tierpsychol. 32:75-105.

WALLBANK, T. W. 1958. A short history of India and Pakistan, A Mentor Book. The New American Library, New York.

WEIZEL, R., and H. P. FORTMEYER. 1965. Zur Nematodenfauna der Hirschziegenantilope *(Antilope cervicapra)* und ihrer Wirtsspezifität. Z. Parasitenk. 25:342-349.

WHITE, G. 1837. The natural history of Selborne, new ed. with notes by E. T. Bennett and others. Fraser & Co., London. 356 pp.

WHITE, I. G. 1968. Mammalian semen. *In*: E. S. E. Hafez, ed. Reproduction in farm animals, 2nd ed. Lea & Febiger, Philadelphia. Pp. 39-59.

WHITNEY, M. 1916. Field operations of the Bureau of Soils, 1913, 15th rep. USDA, Bureau of Soils. 2,438 pp.

WOOD, A. J., H. C. NORDAN and I. M. COWAN. 1961. The care and management of wild ungulates for experimental purposes. J. Wildl. Manage. 25(3):295-302.

WRIGHT, A. 1972. Operation blackbuck. Oryx. 11(4):228-230.

WRIGHT, J., ed. 1831. A natural history of the globe, of man, of beasts, birds, fishes, reptiles, insects and plants, II, new ed. Collins and Hannay, New York. 569 pp.

WRIGHT, P. A., E. F. DEYSHER and C. A. CARY. 1939 Variations in the composition of milk. *In*: Food and life: yearbook of agriculture 1939. USDA Washington, D.C. Pp. 639-648.

WURSTER, D. H., K. BENIRSCHKE and H. NOELKE. 1968. Unusually large sex chromosomes in the sitatunga *(Tragelaphus spekei)* and the blackbuck *(Antilope cervicapra)*. Chromosoma. 23(3):317-323.

YAMAGUTI, S. 1958. The digenetic trematodes of vertebrates, I, Systema helminthum. Interscience Publishers, Inc., New York. 1,575 pp.

_____. 1959. The cestodes of vertebrates, II, Systema helminthum. Interscience Publishers, Inc., New York. 860 pp.

_____. 1961. The nematodes of vertebrates, III, Systema helminthum. Interscience Publishers, Inc., New York. 1,261 pp.

YEH, L-S. 1959. A revision of the nematode genus *Setaria* Viborg, 1795, its host-parasite relationship, speciation and evolution. J. Helminthol. 33(1):1-98.

ZARROW, M. X. 1968. Hormones of reproduction. *In*: E. S. E. Hafez, ed. Reproduction in farm animals, 2nd ed. Lea & Febiger, Philadelphia. Pp. 3-26.

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